PLANTERS' RECORD

VOL. XXIX

A quarterly paper devoted to the sugar interests of Hawaii, and issued by the Experiment Station for circulation among the plantations of the Hawaiian Sugar Planters' Association.

JANUARY TO DECEMBER

THE HAWAIIAN PLANTERS' RECORD

VOL. XXIX

ORGAN OF THE EXPERIMENT STATION OF THE HAWAIIAN SUGAR PLANTERS' ASSOCIATION

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Variety Areas

Statistics now being compiled show the area of H 109 for the 1925 and 1926 crops to be about 78,000 acres. This almost equals the area of Yellow Caledonia which has dropped to about 80,000 acres for the two crops in question.

There are now less than 6,000 acres of Lahaina.

The area of D 1135 is now about 35,000 acres, an increase of about 5,000 acres since a year ago.

The increase in H 109 in a year's time amounts to 12,000 acres.

The reduction in the area of Yellow Caledonia is nearly 10,000 acres.

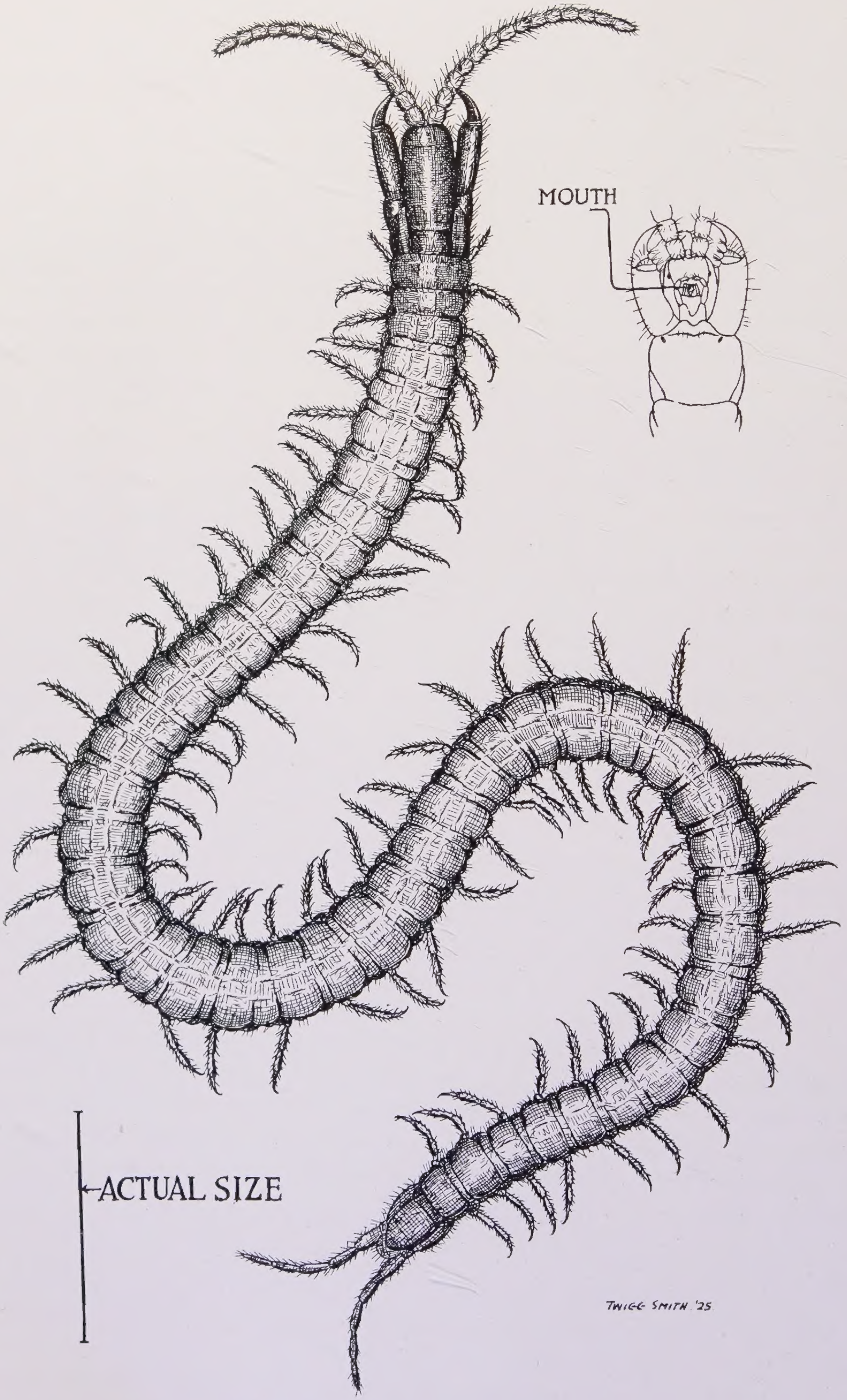
The Early History of D 1135

The cane variety D 1135 was imported into Hawaii from Queensland about 1901 or 1902. We have written to Australia and to Demerara for the early history of this variety.

Mr. C. Ernest Young, of Fairymead Sugar Company, Limited, of Bundaberg, Queensland, tells us that D 1135 was imported by his plantation from Demerara in 1895 with other seedlings from Barbados, Trinidad and Demerara.

Sir John B. Harrison, of Georgetown, British Guiana, confirms this in saying that his records show that D 1135 with some fifty other sorts was sent at the request of Sir Neville Lubbock to Queensland in 1895.

D 1135 was raised in 1892 by G. S. Jenman and Sir John B. Harrison. D 1135 was a seedling of D 103, and the latter is thought to be a seedling from a cane known as Caledonian Queen, presumably a strain of White Transparent.



Mecistocephalus maxillaris

Specimens of this centipede were sent by P. H. Timberlake to R. V. Chamberlain, of the Museum of Comparative Zoology, Cambridge, Mass., for identification in August, 1922. In reply, Mr. Chamberlain gave the identification as above, stating that the "species is widespread in the warmer parts of this Hemisphere, being particularly common in South America and the West Indies," occurring also "at various places in Polynesia and has previously been recorded from Hawaii."

Cane Root Injury by the Centipede, *Mecistocephalus maxillaris*

By C. E. Pemberton

Since my original belief in 1922 that the soil-inhabiting centipede, *Mecistocephalus maxillaris,* was responsible for a great deal of the root hole injury appearing on the roots of cane in Hamakua and Kohala, I have periodically made small experiments to further verify the contention, together with frequent examinations of roots in the field. The experiments were never very satisfactory, my time was mostly occupied in other work and I have always felt that the original work needed some confirmation before this centipede could be considered of any real importance.

I have always experienced difficulty in growing cane roots in culture, having vigor and size comparable with roots growing in the field. Small, weak roots springing from the seed-piece do not appear acceptable. Repeated failures, when using such roots in culture, often led me to believe that the centipedes only rarely attacked them. Mr. McGeorge's paper in the July, 1924, *Record,* describing similar difficulties and explaining his solution of the trouble by growing only roots springing from shoots and not borne by the fermenting seed-piece, also solved my difficulty. I have planted "lalas," or shoots, which were entirely removed from the stick on which they grew. Roots from these have been satisfactory.

In a total of 30 tests in sterile soil, using 260 centipedes all told, and 342 roots, 152 holes and lacerations have appeared on the roots, these being in the soil with the centipedes from 1 to 4 days only, except No. 12, which lasted twelve days. These root wounds are identical in their varied shapes and sizes with those appearing on cane roots in the field.

The separate experiments were as follows:

(1) One adult centipede placed in glass jar filled with sterile soil September 22, 1924, in which one cane root 1½ inches long was inserted, the root being from sterile sand where it was grown. In 24 hours the root was removed. The growing tip was eaten out and 2 large irregular holes, penetrating well into the central cylinder, had been made. These holes, about 2 mm. in diameter, occurred on the last half-inch of the root.

(2) One adult centipede placed in glass jar filled with sterile soil September 28, in which 4 sound cane roots, each about 2 inches long, were inserted, the roots having been grown in sterile sand. The roots were removed and examined 18 hours later. The growing tips of three of the roots were completely destroyed. The fourth root was untouched.

(3) One adult centipede placed in glass jar filled with sterile soil September 29, in which 2 sound cane roots, previously grown in sterile sand, were placed. Upon examination 24 hours later, the growing tip of one root had been completely eaten out. The other root remained sound.

(4) One adult centipede placed in glass jar filled with sterile soil September 29, in which 1 sound cane root, grown in sterile sand, was inserted. Examined 24 hours later. The growing tip had been hollowed out.

(5) One adult centipede placed in glass jar filled with sterile soil September 30, in which 1 sound sand-grown root was inserted. Two hours later, upon examination, the growing tip was completely hollowed out. In this instance, the centipede could be observed working on the root, which lay in the soil next to the glass.

(6) One adult centipede placed in glass jar filled with sterile soil October 2, in which 2 sound cane roots, grown in sterile sand, were inserted. Upon examination 24 hours later, each root had the growing tip completely hollowed out.

(7) One adult centipede placed in glass jar filled with sterile soil October 3, in which 3 sound cane roots, grown in sterile sand, were inserted. Half an hour later, the centipede was observed with its head well into the growing tip of one root, the root lying next to the glass.

(8) Five young centipedes placed in glass jar filled with sterile soil October 7, in which 4 sound sand-grown roots were inserted. Upon examination 24 hours later, 2 roots each had 1 small, deep, circular hole through the cortex near the tip.

(9) Three young centipedes placed in glass jar of sterile soil October 11, in which four sound sand-grown roots were inserted. Upon examination October 13, two of the roots each had one small circular hole into cortex near end.

(10) One young centipede placed in glass jar of sterile soil October 11, in which 5 vigorous sand-grown sound roots were inserted. Upon examination October 13, one root had one small circular hole through cortex near tip. The other roots were sound.

(11) One adult centipede placed in glass jar of sterile soil October 11, in which 5 sound sand-grown cane roots were inserted. Upon examination October 15, the growing tips of two of the roots were completely destroyed. The other roots remained sound.

(12) One adult centipede placed in glass jar of sterile soil October 11, in which a cane seed-piece, bearing 9 sound sand-grown roots, was placed. Examined October 15. The growing tips of two of the roots were completely destroyed and another root was almost eaten in half one-fourth inch from tip. The other roots remained sound.

(13) One adult centipede placed in glass jar of sterile soil October 20, in which 2 sound sterile soil-grown cane roots were placed. Examined October 22. The entire end of one root was consumed for a distance of one-eighth inch and the other root was eaten into and almost severed one-fourth inch from tip.

(14) Eight young centipedes placed in jar of sterile soil October 20, in which 2 sound sterile soil-grown cane roots were placed. Examined October 22. One fairly large circular hole in 1 root one-fourth inch from end and 1 small circular hole in other root one-half inch from base.

(15) Eight young centipedes placed in glass jar of sterile soil October 20, in which 2 sound sterile soil-grown cane roots were inserted. Examined Octo-

ber 22. Only 1 centipede remaining alive. One small oval hole in one root through cortex, marking surface of central cylinder, one-fourth inch from base.

(16) One adult centipede placed in glass jar of sterile soil October 22, in which 2 sound, sterile soil-grown roots were inserted. Examined October 23. The end of 1 root was destroyed for one-fourth inch; only a few threads of fiber left at end. Other root untouched.

(17) Eight young centipedes placed in glass jar of sterile soil October 22, in which 3 sound, sterile soil-grown cane roots were inserted. Examined October 24. The tips of all 3 roots hollowed out. One root also had 1 small, circular hole through cortex one and one-half inches from tip, and another small, circular hole through cortex two inches from tip.

(18) Eight young centipedes placed in glass jar of sterile soil October 25, in which 6 sound sand-grown cane roots were inserted. Examined October 27. Two roots each had 1 small, circular hole through cortex one-eighth inch from end. The other roots were sound.

(19) Eight young centipedes placed in glass jar of sterile soil October 25, in which 3 sound sand-grown cane roots were inserted. Examined October 27. One root had one small circular hole through cortex one-fourth inch from end, and a circular hole 1 mm. in diameter through cortex one-half inch from end. The second root had 1 circular hole 1 mm. in diameter through cortex one-fourth inch from end. The third root had 1 small circular hole through cortex one-fourth inch from end.

(20) Eight young centipedes placed in glass jar of sterile soil October 25, in which 2 sound sterile soil-grown roots were inserted. Examined October 27. One root had 5 small, circular holes, well into cortex, one-half mm. in diameter, all from one-fourth to one inch from tip. The other root was untouched. It was not so vigorous a root when inserted in the jar.

(21) Two adult centipedes placed in glass jar of sterile soil October 25, in which 6 sound sand-grown cane roots were inserted. Examined October 27. One root had tip badly lacerated and a large jagged hole through cortex into central cylinder one-fourth inch from tip. No injury to other roots.

(22) Twenty young centipedes placed in glass jar of sterile soil October 28, in which 7 sound sand-grown cane roots were inserted. Examined October 31. One root had 3 small, circular holes through cortex within one-fourth inch of end, one root had 1 small, circular hole through cortex one-eighth inch from end, and one root had one small, circular hole through cortex one-fourth inch from end. Roots not vigorous.

(23) Ten young centipedes placed in glass jar of sterile soil November 4, in which one cane eye with roots just starting was inserted. Examined on November 8. Of 42 roots, which had reached lengths varying from one-fourth inch to two inches, 10 each contained one small, circular hole from one-fourth to 1 inch from end.

(24) Ten young centipedes placed in glass jar of sterile soil November 4, in which 1 cane eye, with roots just starting, was inserted. Examined November 8. Of 38 roots present, which had grown to lengths of one-fourth to two and one-half inches, 5 each had 1 small, circular hole through cortex near tips.

(25) Ten young centipedes placed in glass jar of sterile soil November 4, in which 1 cane eye, with roots just starting, was inserted. Examined November 8. Of 58 roots present, varying in length from one-fourth to two inches in length, 7 each had 1 small, circular hole through cortex near tip.

(26) Ten young centipedes placed in glass jar of sterile soil November 4, in which 1 cane eye, with roots just starting, was inserted. Examined November 8. Of 35 roots present, varying in length from one-fourth to two and one-half inches, 4 each had 1 small, circular hole through cortex near tip, and a fifth root had 2 small, circular holes through cortex near tip.

(27) Ten young centipedes placed in glass jar of sterile soil November 4, in which 1 cane eye, with roots just starting, was inserted. Examined November 8. Of 45 roots present, varying in length from one-fourth to three inches, 5 each had 1 small, circular hole through cortex near tip.

(28) Thirty young centipedes placed in wooden box 10 x 6 x 6 inches, filled with sterile soil November 8, in which 3 lalas or cane shoots were planted. None of the cane stick itself being attached excepting a very small bit for support at the bases of the shoots. Examined November 14. Fifteen roots, all vigorous, had grown out from one to three inches in length. A total of 18 small circular holes, mostly through cortex, were counted on 11 of the roots. Four of the roots remained sound. The holes ranged from one-half to two and one-half inches from tips of roots. These roots could not have been present for more than 4 days.

(29) Fifty young centipedes placed in box as in Experiment 28, November 21, in which 3 lalas were planted on same date. Examined November 28. Sixteen roots from one-half to two inches in length had appeared. On 13 of them a total of 19 small, circular holes, mostly through cortex, were present. Three roots remained sound.

Since recording Experiment No. 29, a further test, No. 30, has been completed, which is of interest. On December 4, 2 lalas were planted in a box of sterile soil, containing 40 young centipedes. This was examined on December 16. The cane roots produced in this box were thus exposed to centipede attack for about 12 days, which is about a week longer than in any of the previous experiments. A total of 16 roots had appeared, from one-half to four inches in length, bearing a total of 31 holes or lacerations, made by the centipedes. None of the roots were uninjured. Four of the roots had the growing tip completely destroyed. Three other roots bore one hole each near the center, which not only penetrated the cortex, but extended so far into the central cylinder that the root was nearly severed in half. These three roots were badly rotted. The remaining nine roots had from 1 to 5 of the typical, small, circular holes through the cortex.

Checks on the above experiments follow:

(1) All centipedes were picked out of the soils in jars of Experiments Nos. 18, 19, 20, 21 and 22 October 28, without otherwise disturbing or treating the soil. In these jars, sound, sterile soil-grown roots were inserted October 28, there being 4, 4, 4, 3 and 2 roots to the 5 jars respectively. These were removed and carefully examined November 30. All were perfectly sound and bore no holes.

(2) All centipedes were picked out of the soil in Experiment Box No. 28 and 4 clean lalas, or shoots, without roots, planted in the soil, without otherwise treating the soil, November 14. Examined November 22. Thirty-two vigorous young roots from one-half to three inches long were present. All were absolutely sound and bore no holes.

In all of the above experiments, it should be noted that in no case were the roots exposed to centipede attack for much more than 4 days, if that long. No great success was had in working with the young centipedes until the method adopted in Experiments 28 and 29 was used, for in the others the roots soon lost their vigor after being changed from sand to soil or one soil to another. The eye plantings were not entirely satisfactory in securing growing roots, as a part of the fermenting stick was planted with the eye and not enough time elapsed for vigorous eye roots to grow.

As the root holes appearing on the roots in the experiments are identical with those found in the field and as this centipede is exceedingly abundant in cane soils in Hamakua and Kohala, where I have searched for it, I ascribe a great deal of this root marking, in these localities at least, to the centipede. Snails, of minute size, are present in the soils here, but I have difficulty finding many of them, excepting in a few spots, and particularly deep in the soil, where roots are penetrating. I find the centipedes following the roots at all depths, however.

Paradichlorobenzene is highly fatal to the centipedes.

On November 22, 1924, I placed 60 freshly collected centipedes in a wooden box containing 220 cubic inches of slightly moist soil. Into this I mixed three-fourths ounce by volume, of paradichlorobenzene. Two days later, upon examination, all centipedes were dead and only a small amount of the chemical had disintegrated.

On November 25, I placed 60 more freshly collected centipedes, 3 being adults, in the same amount of soil and mixed in one small teaspoonful of paradichlorobenzene. Twenty hours later found them all dead.

On November 26, I cleared away all grass and trash from 10 feet of row of 1-year old Yellow Caledonia cane. This space bore 22 sticks of cane. Over the surface of this space I sprinkled 3 ounces of paradichlorobenzene, the area being 10 feet long by 2½ feet wide, and loosely covered the chemical with one-half inch of soil. Two days later I removed from this soil 62 centipedes at depths ranging from 2 to 9 inches, 41 of which were dead. There were 10 adults, only 1 being alive. As most of the flakes of the chemical were still present, its poisonous fumes would no doubt continue to operate for many days longer and a higher percentage of dead would have been found if I had waited longer. The soil still smelled strongly of the substance.

This material may prove of great value to us, as a soil fumigant, in time, if soil fumigation should prove useful by later experiment. I have no data at hand as to its cost.

The Duty of Labor*

By J. S. B. Pratt, Jr.

A subject that has not been discussed much at our meetings, or at the Planters' meeting, is the "Duty of Labor." By this we mean, how much a man can do on the various tasks in a day. And connected with this is, how can we get that man to do more?

The duty of labor is a matter of conditions. That is the reason it is so difficult to present a paper on this topic. One immediately says, "Our conditions vary so much even on our own plantation." We hear the statement, "Ten years ago our laborers did much more work than they do now." How do we know? Do we have a standard of comparison, or are we thinking of the outstanding individuals?

Feeling that it was a subject we plantation men are all interested in, and want to discuss, the writer sent out a large number of questionnaires. Replies were received from J. T. Fantom, of Puunene; A. T. Spalding, of Honomu, and W. L. S. Williams, of Waiakea, and their answers helped materially in this paper. The rest of the material presented comes from the writer's own experience on different plantations, and from copious notes taken in travels to all the plantations.

Plantation Labor Requirements

An easy ratio to remember for labor required for a plantation, is one man to 5 acres for the irrigated places, and one man to 7 acres for unirrigated. This includes all labor: mill, field, sundry, etc., or is the total labor to the total acres in cane.

Approximately 65 to 70 per cent of the total labor is actually engaged in raising and harvesting the cane. The 35 to 30 per cent balance is for the mill, construction, overhead and sundry jobs. It can be estimated that most plantations use 10 per cent of the total labor in the mill, with the other 20 to 25 per cent overhead, repairs, sundry and construction jobs. The percentage for the mill depends on the size of the plantation.

During the harvesting season, 20 to 25 per cent of the total labor is required for the harvesting fields, divided roughly as follows: 15 per cent for hauling and track, 40 per cent for loading, 45 per cent for cutting.

The labor requirement per ton of sugar is influenced by the yield per acre, and the quality of the juices, but the above mentioned ratios are good approximations per acre.

Man vs. Woman Labor

Although a woman's rate of pay is usually 75 per cent that of a man's, there are certain operations in which she can equal a man day's work. Irrigating, weeding, fertilizing, picking up cane, piling cane, cutting seed, setting seed,

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

covering and planting are all operations in which she may excel, depending largely on the individual and on the luna. But as these operations are generally on a contract basis the pay is based on the work actually done. All lunas cannot handle wahine gangs or school children gangs, and it pays to find good lunas for them. Better work is done by wahine gangs if they are separated from the men.

Child Labor

School children of advanced age often work for short periods of time. The superintendence of school children is mild, and they work at the easier jobs, as in setting seed in planting, in which they excel. As with the school gardens, this light plantation work has great educational value in teaching proper agricultural practices, and in stimulating an agricultural interest.

Handling Labor

In Hawaii, we find three main schemes for handling labor:

(1) Day work;
(2) Piecework or ukupau;
(3) Contract work.

Add to this, a possible fourth, the combination of ukupau and contract work.

In (1), we have the most expensive and slowest work. Certain jobs requiring careful work as in weeding in young plant cane may be best done by day work. Here the overseer must see that the man gets a day's work done.

In (2), a certain task is given, as for example, to cut ten bags of seed and pack to the cars, or to hoe forty lines of cane. This system works well with the psychology of a large amount of our labor, that is, the thought that when the task is completed, he can go *home.* This method requires closer supervision to see that the task is done well, but at least a day's work is done. Ukupau is a good system where the overseers are on the job, but careless work results unless they are. The tasks should not be set by the sub-lunas, as they often want to go home as badly as the men do.

In (3), contract system, we find a method very common in the Islands. The term "Long Term Contracts" usually refers to the growing of cane, often over a two-year period, under contract. Remuneration is received from tonnage raised. "Short Term Contracts" are petty contracts for short periods of time. By this, a man is paid for a certain task, and the more work accomplished the more money he earns. Here, the overseer does not have to urge the men on, but devotes his time to seeing that careless work is not done. A man is justly paid for what he earns. A contract may be taken by a group of men or by individuals.

The fourth method of a combined ukupau and contract is being used more and more by plantations. By the ukupau method (3), all men in the gang usually get the same task and receive the same money per day. The contract system when individual, gives the man what he earns. Some places combine these methods, i. e., when a man earns by contract a set amount, usually say 10 per cent above his daily base rate, he is allowed to go home (like ukupau), but he may stay to earn more (contract method).

The writer believes this is the best method, where applicable, with our present laborers. The way to get the most work out of a man is to place him on an individual task. The good man gets more money than the poor man. This combined contract and ukupau is ideal in that the home psychology enters, and yet a man may do more than under ukupau. It works nicely in hoeing contracts, and several plantations use it in cutting cane.

It would be a big mistake to cut a rate when it has been set incorrectly and a man is making big money. The rate is based on so much per acre, or per line, etc., and what an individual makes is not the criterion; but what is, is our cost per acre or per ton cane. The more a man earns at that rate, the more work we are having accomplished. The most success in handling contracts is obtained by sticking to a rate while the job lasts, or the conditions remain the same, and if one has made a mistake in setting the rate, to learn not to do it next time.

It is equally as bad to have a contract and do as many plantations do, figure out the contract after the month or job is over at a certain rate. This is no contract at all, and the making up of a contract up to a certain amount is also bad. Pay them what they earn.

On Increasing Our Duty of Labor

(1) Inculcate the idea of money earning in the men.

(2) Better overseers, and closer instruction of them.

(3) Have the overseers train the individuals in the details, as in the correct way to use the hoe, to cover seed, or to cut cane.

(4) Short cuts. The interesting part to our plantation work is that there is always something new coming up. Simply because a job has been done a certain way for the last fifty years is no reason that it should be done that way another fifty years. We may have a new cane requirement, conditions may have changed, or we may have been making mistakes for fifty years. So, study the details, and look for short cuts.

(5) See what your neighbor is doing. Travel around and get out of the rut. He may be doing your job in a quicker way than you are. "Talk shop" with him.

(6) There are many unnecessary jobs or motions; cut them out.

(7) The only way to increase the duty of labor is to first find out what your labor is doing. How much are my men irrigating per day, how many tons cane can they cut, etc.? Finding out this, one automatically tries to do better, but unless one knows what his men can do, he may never hope to get more work out of them.

(8) Do the job at the right time. Try to get the weeds, for instance, when they are light rather than when they are heavy, for heavy weeding takes the pep out of the men. It is better to do two light cultivations than one heavy cultivation.

Conditions vary, and averages do not show much, but we all like to hear how the other fellow is doing it. Yet, by experience we all come to have an idea of what a day's work is, else we could not set any contracts. We know a man cannot cut twenty tons of cane a day, but we have a range of say four to eight tons in our mind as a day's work. The new man coming in to the industry wants to

know, so it is hoped that the accompanying tables will be taken as a "starter" on this important subject, and that others may add to this each year.

The items are lettered and discussed under the headings after the table.

TABLE SHOWING APPROXIMATE RANGES FOR A DAY'S WORK (10 HOURS)

OPERATION—

A. Clearing: Rock (heavy), 60 men per acre.
Lantana, 4 to 10 men per acre.
Koa, 5 to 20 men per acre.
Guava, 10 to 20 men per acre.

B. Steam Plowing:

Plowing: Acres plowed per day, 4 to 8 acres.
Men per acre, 1 to 4 men.

Harrowing: Acres per day, 10 to 35 acres.
Men per acre, 1/2 to 1/7.

C. Caterpillar Plowing and Harrowing:

3 disc gang plow: Acres plowed per day, 4 to 7.
Men per acre, 3/4 to 3/7.

Harrowing: Acres harrowed, 15 ±.
Men per acre, 1/5.

Plowing*: *Engine gang, 4–14″, 2 men, 14–18 H. P., 8 acres per day (10 hrs.).
*Engine gang, 4–14″, 2 men, 20–25 H. P., 12 acres per day (10 hrs.).
*Engine gang, 4–14″, 2 men, 25–30 H. P., 16 acres per day (10 hrs.).

D. Animal Plowing:

*Walking plow 12″, 1 man, 2 horses, 1.6 acres per day (10 hrs.)
*Walking plow 14″, 1 man, 3 horses, 2.3 acres per day (10 hrs.).
*Sulky Plow 14″, 1 man, 3–4 horses, 2.5 acres per day (10 hrs.).
*Gang 2–14″ bottoms, 1 man, 4–6 horses, 5.2 acres per day (10 hrs.).
*Gang 2–12″ bottoms, 1 man, 3–6 horses, 4 acres per day (10 hrs.).
*Gang 3–12″ bottoms, 1 man, 5–8 horses, 6.6 acres per day (10 hrs.).
*Gang 2–8″ bottoms, 1 man, 2–3 horses, 2.8 acres per day (10 hrs.)
*Gang 3–8″ bottoms, 1 man, 3–4 horses, 4.2 acres per day (10 hrs.).
*Deep tillage 2–20″ disks, 1 man, 6 horses, 2.5 acres per day (10 hrs).

E. Animal Harrowing*:

*Disk harrow (not lapped) 4′, 1 man, 4 horses, 5 acres in 10 hrs.
*Disk harrow (not lapped) 6′, 1 man, 6 horses, 9 acres in 10 hrs.
*Disk harrow (not lapped) 8′, 1 man, 8 horses, 14 acres in 10 hrs.
*Spike harrow (not lapped) 8′, 1 man, 2–3 horses, 10 acres in 10 hrs.
*Spike harrow (not lapped) 16′, 1 man, 4 horses, 30 acres in 10 hrs.
*Spike harrow (not lapped) 24′, 1 man, 6 horses, 40 acres in 10 hrs.
*Spike harrow (not lapped) 32′, 1 man, 8 horses, 60 acres in 10 hrs.
*Spring tooth, 6′, 1 man, 3 horses, 9 acres in 10 hrs.
*Spring tooth, 8′, 1 man, 4 horses, 12 acres in 10 hrs.

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* Adams' Farm Management, p. 547.

F. Furrowing:

Caterpillar: 1 Mouldboard, 4 acres per day; 1/2 man per acre.
2 Mouldboard, 8 acres per day; 3/8 man per acre.
3 Mouldboard, 12 acres per day; 1/3 man per acre.
Animals: 1 Mouldboard, 4 animals, 4 acres per day; 1/2 man per acre.

G. Preparing and Ditching:

(a) Preparing (hukilepo): Men per acre, 2 to 4.
Lines of 30′ per man, 150 to 75.
Canoe plow, 2 horses, 4 acres per day, 1½ men per acre.

(b) Ditching usually 2′ x 2′, 1 man does 75′ per day.

H. Cutting Seed:

Top-seed ahead of cutters—bags per man, 15 to 20.
pounds seed per man, 975 to 1,300.
cutters leaving seed—bags per man, 20 to 30.
Body seed: Bags per man, 30 to 40.
Pounds per man, 1 to 1¼ tons.

I. Hauling Seed:

Pack-saddle: Bags per man, 150 to 350.
1 pack-saddle man to 10 planting.

J. Planting:

Preparing, planting, covering: total men per acre, 4 to 5.
Preparing, 1 to 3.
Dropping and setting seed, 1.
Covering, 1 to 2.
Bags per acre (65 lbs. each), 60 to 80.
Bags per man (setting seed and covering), 25 to 35.

K. Replanting: Variable (1 to 3).

L. Irrigation:

(a) First water 30′ lines—
Lines per day per man, 80 to 200.
Men per acre, 4 to 1½.

(b) Small cane—men per acre, 1 to 2.
With weeding, 2.
Without weeding, 1.

(c) Big cane—men per acre, 3/4 to 1.
Orchard system—first water, 1/4 to 1/6.
Subsequent, 1/10 to 1/20.

M. Cultivation Contracts:

Plant cane, 5 to 10 acres per man.
Ratoon cane, 7 to 13 acres per man.
Total man-days per acre (hoeing and irrigating, long term contracts)—
Plant, 30 ± days per acre.
Ratoon, 20 ± days per acre.

N. Fertilizing (by hand): 10 to 15 bags per man.

Estimated Sliding Schedule—Spreading only—
3 bags per acre, 9 bags per man, 1 man 3 acres.

4 bags per acre, 10.5 bags per man, 1 man 2.6 acres.
5 bags per acre, 11.5 bags per man, 1 man 2.3 acres.
6 bags per acre, 12.5 bags per man, 1 man 2.0 acres.
7 bags per acre, 13 bags per man, 1 man 1.8 acres.
8 bags per acre, 13.5 bags per man, 1 man 1.7 acres.
10 bags per acre, 14 bags per man, 1 man 1.4 acres.
125 lb. bags.

Bags packed per day—100 per man.

By wagon:

1000 lbs. per acre, 2 horses, 1 man—45—60 bags per man.

* **Manure Spreader** (75 bu.):

1 man, 2 horses; loads in 10 hours—12.

* **Spreading Lime:** drill (10′):

1 man, 2 horses; acres per day—11.

* **Spreading fertilizer:**

1 man, 2 horses; acres per day—13.

O. Hoeing:

Light weeding: Men per acre, 2—4.
Lines (30′) per man, 150—75.
Medium weeding: Men per acre, 4—8.
Lines (30′) per man, 75—40.
Heavy weeding: Men per acre, 8—12.
Lines (30′) per man, 40—25.

P. Cutting Back:

No hoeing (knives):
Men per acre, 2/3 to 1.
Lines (30′) per man, 200—300.
With hoeing (hoes):
Men per acre, 2—4.
Lines per man, 75—150.

Q. Harvesting, Irrigated:

1 good man cuts in 30 tons cane burned about 8 tons.
1 poor man cuts in 30 tons cane burned about 5 tons.
1 good man cuts in 30 tons cane unburned about 4½ tons.
1 poor man cuts in 30 tons cane unburned about 3 tons.
1 good man cuts in 60 tons cane burned about 9 tons.
1 poor man cuts in 60 tons cane burned about 6 tons.
1 good man cuts in 60 tons cane unburned about 5 tons.
1 poor man cuts in 60 tons cane unburned about 3½ tons.

Loading: Burned cane, 10 to 15 tons per man.
Unburned cane, 8 to 10 tons per man.

Portable track: Lay and take up, about 240 ft. per day.

Ratio: Trackmen to cutters, 1 to 5.
Loaders to cutters, 4 to 5.

Harvesting, Unirrigated:

1 good man cuts and packs to flume 3½—4 tons cane.
1 poor man cuts and packs to flume 2½—3½ tons cane.
1 good man cuts in burned cane 5—7 tons.
1 good man cuts in unburned cane 3—5 tons.

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* Adams' Farm Management.

1 poor man cuts about 3½ tons.
Loading to flume—tons per man, 6—8 tons.
Fluming per man 20—30 tons.
Pickups—Ratio: pickups to cutters 1 to 50.

R. **Palipali: Medium Trash:**
Men per acre, 2—3.
Lines (30′) per man, 100.
Lines (210′) per man, 19—20.

S. **Stripping:** Men per acre, 2—6.

T. **Cultivation:***

*24″ space,	1 man,	1 horse,	4	acres in 10 hours.
*30″ space,	1 man,	1 horse,	5	acres in 10 hours.
*42″ space,	1 man,	2 horses,	6½	acres in 10 hours.
*48″ space,	1 man,	2 horses,	7½	acres in 10 hours.
*66″ space,	1 man,	2 horses,	10	acres in 10 hours.
*84″ space,	1 man,	2 horses,	12	acres in 10 hours.

Big Horners going once: acres per man, 2¾.
twice: acres per man, 2.
Planter Jr. once: acres per man, 4.
twice: acres per man, 2.

Hilling Up:
Plows only: men per acre, 3—5.
animals per acre, 2—2½.
Canoe Plows: acres per day, 4.
men per acre, ¼ to ½.

Off-barring:
Men per acre, ½.
Animals per acre, 1.
Tractor, small, acres per day, 12.
Tractor, 3-10″ plows, 4 men, acres per day, 8.

U. **Miscellaneous:**
Poepoe—Lines per man, 75.
Spraying—Acres per man per day, 1¼.
Seed sprayer—Acres per man per day, 5.
Track: Main line—
Ties dipped per man per day, 200.
Ties dipped per 50 gal. bbl. (4″x6″x5′), 700.
Ties tamped per day per man, 90.
Feet spiked and fish-plated—180 feet for 2 men.
Take up old rail, put in new—3 men per 100 feet.
Track Maintenance: Daily per mile—1 man.
Fences:
Holes dug per man per day, 35—40.
Holes tamped per man per day, 50.
Fence put in, stringers and all, feet per day per man, 50.
Old fence taken up, feet per man, 75—100.
Take up and put in, feet per man, 30.
Posts dipped per man per day, 300.
Posts dipped per 50 gals., 1000.

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* Adams' Farm Management.

Forestry:

Dig holes, plant and irrigate: trees per man, 40—50.

Clear brush, dig holes, plant and water: trees per man, 40.

Concrete:

1 man should average 1½ to 1¾ cu. yds. concrete in 8 hrs., including mixing and wheeling not more than 50 ft. (Farmer's Bul. 1279.) — 1½—1¾ yds. per man

Earthwork:*

* Loosening—Pick: ordinary loam, 3—5 cu. yds. per hr.
* hardpan, .5—1 cu. yds. per hr.
* Plow: ordinary loam, 40—50 cu. yds. per hr.
* (4 men) clay, 25—30 cu. yds. per hr.
* hardpan, 15—20 cu. yds. per hr.

Shoveling:*

* Pick and shovel—yds. per man, 7 cu. yds. per day.
* Loosened earth to wagon, 1.2 to 1.5 yds. per hr.
* Loosened earth from platform, 2—2.5 yds. per hr.
* Spade and load: brick clay, 20—40 cu. yds. per day.
* Pick and load: loam, 1 cu. yd. per hr.
* stiff clay, ¾ cu. yd. per hr.
* hard-pan, ⅓—½ cu. yds. per hr.

Scrapers:*

*Fresno scraper, depending on length of haul and soil: yards per day, 60—120 cu. yds. per day.

Wheelbarrows:*

* Pick and load into wheelbarrows, loam per man, 1 cu. yd. per hr.

Digging cesspool—8′x8′x10′: Sq. ft. per day, 75.

Digging ditch—2′x2′: Feet per man per day, 75.

Tunnels: **Example**—3′x5′ soft earth, 32 ft. long: Feet per man per day, 4½.

Sand: Waianae sand—Lbs. per cu. yd., 2400—2600.

Cu. ft. per ton, 31.

Yds. sand load in car per day, 15.

Yds. sand unload from car per day, 20.

Rock: Loading crushed rock in bags per man, 50.

Breaking large rock for crusher: Yds. per man, 3½.

Stone wall: 3′x3½′—Rock nearby: Feet per man per day, 13—20.

Firewood: Cords per man per day, 1—2.

Cane-tops to stable: Ratio, men to animals, 1 to 50 or 100.

Discussion

A. *Clearing:* This operation usually refers to the taking in of new land. Removing rock, cutting brush, or otherwise getting the land ready for plowing is termed "clearing." One plantation has done extensive rock clearing, piling the rock in large piles in the field. The rocks are plentiful and 12 men can clear only 5 acres per month, or 65 men per acre with the aid of two steam plows dragging sleds or chains. Some plantations have brush or koa, taking as many as 20 men per acre grubbing. Lantana may take 5 to 20 men per acre grubbing, depending on rocks present.

* American Civil Engineers Hand-Book.

B. *Steam Plowing:* The size of the field, topography, depth plowed, condition of soil, amount of trash or rocks cause the men per acre to vary.

For an entire season, one plantation averaged 5 men per acre, to include two plowings and two harrowings. One set of steam plows plows between 4 to 8 acres per day with a total of 2 drivers, 1 on water and fuel, 4 on plow, or a total of 7 men. In very rocky land, one set may not make more than 2 acres per day. With no rocks, one set averaged 9 acres per day over a 300-acre field on first plowing. With a flexible tooth harrow, 12 feet wide, 18 acres were steam plow-harrowed in this field. On level land in large fields, with the disc harrow, 35 to 50 acres per day may be done. Approximately half of the total plowing cost is for labor.

A saving in man and animal labor has been made by several plantations recently, by substituting a small tractor to pull the water and fuel carts, one tractor pulling two water wagons with fuel.

C. *Caterpillar Plowing and Harrowing:* With a 60 H. P. tractor, and 3 gang disc plow, 6 acres per day is good plowing, or one-half man per acre. Plowing on a 24-hour shift, the pineapple people figure 15 acres for the 24 hours, or 7 acres per day. Good land is plowed at night, the poorer stretches in the day. Between 4 and 7 acres is good caterpillar plowing for a 3-disc gang plow, using 3 men. "An average duty of machinery is 1.4 acres as a day's work for each foot wide that a machine covers." (Warren's Farm Management.) A small type tractor can harrow 5 to 8 acres per day. The amount of harrowing done depends on the speed and width, but a good figure is "1.5 acres per foot of width, with 2 acres per foot width for plows." (Adams' Farm Management.)

D. Animal plowing is done in only the small, unhandy places where the tractors cannot work. The amount of work per man and animal would vary for that reason. The table gives some mainland standards.

E. The table gives animal harrowing figures on the mainland.

F. Perhaps the factor most affecting a good day's work in furrowing is topography. If there are many turns, the area furrowed is cut down considerably. The area furrowed also depends on the width of row; perhaps 5 feet apart is more commonly used. Furrowing is often done on Hawaii by 10" plows run both ways in the line.

G. *Preparing, Called "Hukilepo":* This operation is done very thoroughly on the irrigated plantation to give a good furrow for water. The amount of preparing depends on the soil texture. If grassy and lumpy, a man may only make 100 lines of 30-foot length per day. Then again he may make 150 and up to 200. A big labor saver has come in the use of the canoe plow (modified celery hiller). This makes the furrow after mouldboarding in excellent condition to plant, in fact, often no further preparing is needed except on the field edges. One big horse can be used, and it is best to change off at noon. More often two animals pull one canoe plow. One man can drive it, but if there are many curves and turns, two men make a better job. They may do 4 acres a day. "Hukilepo" in ratoons comes under the term hilling-up. Seventy-five to 150 lines of 30-foot will be a day's work on this operation.

Ditching, for irrigated plantations, is most often done by pick and shovel. Seventy-five feet for a 2′x2′ ditch is good, but this cannot be done if there are any rocks.

H. *Cutting Seed:* If any plantation job requires knack, it is seed cutting. An expert cutter can cut three times the amount a poor cutter might cut. It pays to weed out the poor seed cutters and instead of having a large gang giving harder supervision, to have a small gang of reliable seed cutters. The amount cut per man varies a great deal with the stand of the cane. A man cuts much more seed in heavy cane. He loses less time. Some places pay so much per bag loaded to the cars, others leave the seed in the field and have packmen pack the seed out. The writer believes it best to have the men cut the seed, get it inspected before sewing at the outside of the field, then at the end of the day, have each man place his seed on the car or truck. Some new seed cutters may only make 8 to 10 bags per man, while expert cutters can make as high as 35 to 40 bags and pack same out. Some places require the men to sew their own bags, others have men to sew and throw out poor seed, and to make full bags. 15 to 20 bags is perhaps a standard figure per man for top seed.

I. *Hauling Seed in the Seed Cutting Field and Planting Field:* Excellent packsaddle men are hard to get. An ordinary man may pack only 150 bags per day, whereas a good packman can pack 350 bags per day. The number of pack animals and distance have a bearing on amount packed.

J. *Planting:* Preparing, dropping seed, setting and covering will take about 5 men per acre. On irrigated places add 3 men more for first water. Assume we have a 20 men gang. We may use 2 men on packsaddle, 5 men hukilepo (preparing), 2 men dropping seed, 1 opening bags, 4 on setting seed, 6 on covering, and we may plant 350 bags, or 5 to 6 acres, depending on the seed spacing. First water on irrigated plantation will take another 2 to 3 men. Between 25 and 35 bags per man is a day's work for setting seed and covering. One unirrigated plantation man figures with a gang of 44 men and boys, 12 will be used for preparing, 1 on packsaddle, 8 on dropping seed and opening bags (boys), and 24 setting and covering; 360-400 bags will be planted, or 9 to 10 bags per man. Here, however, setting seed is done by hand, each seed-piece being placed by hand at an angle depending on the wetness of the soil.

The number of bags per acre and planting rate depends a great deal on the width of rows and spacing of seed, for the number of bags of seed may run from 60 to 100 bags per acre. Figures taken from planting on a plantation over a large field, somewhat hilly, indicate a day's work. One man cut 15 bags seed and packed his own seed to car. One man prepared 200 lines of 30-foot length. One man planted 36 bags, setting and covering, or 125 lines. One man irrigated 90 lines on pali, and 150 on level, putting in trash panis. With a gang of 40 men, 8 were preparing, 13 planting, 19 irrigating. It took 32 men to cut seed for this gang of 40 men.

For sewing bags, 1 pound of twine will tie 120 bags. Figure on one-eighth pound per man.

K. *Replanting:* This varies so much that it is difficult to give even a general idea of a day's work. It depends on the soil in which the seed is being planted,

in the number of openings to be dug and in the amount of replant. No figures are available, but the best way to determine the amount is to estimate what per cent of the lines is the average to need replanting. For instance, if one-fifth of the lines need replanting, we will require about 15 bags per acre for the replanting. Perhaps this will take 2 men a day to complete. Where the replanting is light, the quickest way to do is have each man have a half bag made into a knapsack carrying seed. He makes his own hole, drops his seed and covers it. This keeps the seed and hole from drying out. Where replanting is heavy, do the operations separately.

Irrigation

L. (a) *First Water:* This depends on the system, topography, texture of soil, flow of water, and inches per irrigation. On the first three waters, the water should be shut as it reaches the end of the line, as there are no roots developed. One man can put in panis and irrigate about 85 lines on palis, and up to 200 lines on the level, but a good average figure for first water is 125 lines, with 300 lines per acre.

(b) *Small Cane:* Often if there is no weeding, a man handles two or three watercourses. Then one and a half to two acres may be irrigated per day. Quoting from W. P. Alexander's Bulletin on Irrigation of Cane: "The average was 1.13 acres per man for the standard system before winter, and .76 acre per man in big cane time."

Perhaps a good figure to have in mind is 2 men per acre in the small cane where weeding is done, and 1 man an acre in the large cane. If weeding is taking more than 2 men per acre it is a waste of water, and should be done as a separate operation.

(c) *Big Cane:* The flow of water determines the amount irrigated in big cane. The great difficulty is in preventing an over-irrigation, so the use of the watch is recommended, and a time per line set. Two minutes per line of 30 feet gives about an acre a day with the flow ordinarily used by one man. A man should make an acre a day in big cane. If not, the chances are that the line is being filled too full, resulting in over-irrigation. The writer has found that it is largely a question of overseers as to the speed attained. He has tried switching lunas, and finds that the same men can irrigate fully 50 per cent more with one luna than with another.

The amount per day will be larger when irrigating up a watercourse than when irrigating down, as the panis are already made and the man is less apt to fill the line too full.

Allen reports that "one man with a flow of 77,000 gallons can irrigate 1.375 acres per day by the double line method, and 1.385 acres per day by the single line method."

M. *Cultivation Contracts:* These are termed "Long Term Contracts" and usually run 460 days or 18 months. The contractors do all the cultivation (hoeing and irrigating). The number of acres handled per man varies according to the amount of weeding to be done, and to the number of irrigations. It varies from 5 to 10 acres in plant, to 7 to 13 in the ratoon. An average of all cultiva-

tion contracts for 5 plantations for two years is 8.2 acres per man for both plant and ratoon. The plant fields are more apt to be taken up on contract unless heavy weeding is expected. "Kokua," or extra help, is charged to the contract. One irrigated plantation figures 7½ acres on plant, 8½ on ratoon per man. Another figures 5 on plant and ratoon, 10 and 13 respectively for another place. One irrigated plantation figures 8 to 10 acres on plant per man, 9 to 12 on ratoon.

Days per Acre: Dividing the total number of man-days spent on the contract by the number of acres gives an interesting figure, the days per acre. Taking one plantation, plant cane required 30 days per acre, ratoon 20 days per acre. This included hoeing and irrigating operations only. Hilling-up and fertilizing are usually not charged to the contract. The "days per acre" depends on length of time of contract, weeds and number of irrigations, and speed of the men.

N. *Fertilizing:* Twelve to 15 bags of fertilizer (125 lbs. each) is a good day's work for a man spreading by hand at a 4- or 5-bag per acre rate. New men might spread only 9 or 10 bags. Men who have spread for a long time might make 20 bags per day.

The writer presents a sliding schedule in the table that he has worked out, showing how the rate per acre determines the men per acre. This would vary with the man. Most plantations pay a flat rate per bag regardless of the rate, but a man covers more area with the lighter application, so if a contract is made by acre, a sliding scale should be worked out.

O. *Hoeing by Acre:* Where the grass is very uneven, a contract by acre is the type to give; also when the cane is large, or when one hesitates about trusting a certain luna to count lines. Acre hoeing will take from 2 to 12 men per acre. We very seldom hoe in a field with grass that would take less than two men per acre. The amount of weeds is determined to a great extent by the moisture. Many believe it is as important to get the weeds out of the cane as it is to put water on, for weeds soon dry a field out in dry weather.

By Line: Hoeing by line, either ukupau or contract, is recommended wherever possible, to speed up the labor and to give a good man a chance to make more money. Twenty-five to 150 lines per day, depending on the grass, constitutes a day's work.

P. *Cutting Back:* This operation is done with knives or hoes. Often a hoeing is given at the same time. More often, the trash is allowed to dry and is burned in a couple of days. A man may cut back and hoe only 85 lines, or he may cut back with a knife 300 lines.

Q. *Harvesting:* In Hawaii, most of the plantations burn the trash before harvesting, wherever possible. Where gangs are cutting every day in burned cane, and rains make it so that they cannot burn, one will notice that they may cut fully 50 per cent less cane. It disgusts them, and they do not try. Were they used to it, as on Hawaii where it rains so much and prevents burning, it may only take 25 per cent more men to cut unburned than burned. Where a man cuts 5 tons burned, it can safely be figured that he will cut only 3 tons unburned. A man can cut more cane in hilled-up cane than not hilled, especially if there is trash.

On one irrigated plantation, harvesting gangs for a season averaged about as follows: 450-525 tons cane per day; 55 men cutting; 10 men average on fire-breaks; 45 men loading; 6 on pickups (2 per cent of tonnage was pickups); 13 men portable track; 200 rails laid per day; 15-foot length of rail; 3 rail teams with 2 mules each; 5 drivers hauling cane; 20 animals; 10 brakemen. Certain fields require less hauling, using fewer teams and men. Heavy cane would require fewer men per ton cane for hauling, etc.

On the unirrigated plantations, the same gangs usually cut and then pack to the flumes. The amount of cane flumed will vary as to the grade of the flumes and the water available.

R. *Palipali:* This operation is the piling of the trash in the row, requiring 2 to 3 men per acre. Most plantations burn the trash. The most effective and quickest work can be done in the early morning when the trash is wet.

S. *Stripping:* Most of the unirrigated places give one stripping, taking anywhere from 2 to 6 men per acre.

T. *Cultivation:* With cultivation work, it is very hard to work up a standard. Condition of soil moisture, weeds, rocks and topography are influencing factors. Often cultivators have to go three or four times, so that man-days per acre is variable.

Hilling-Up: After the plows have done the hilling, a certain amount of light hoeing and "hukilepo" or pulling up the soil is necessary. Eighty to 140 lines can be done, 30 feet in length. A line ukupau can be given, but it is fairer to give an ukupau for so many men to a ditch, easily figured when the area is known.

U. *Miscellaneous:* These miscellaneous duty of labor notes are taken largely from the writer's various notebooks from plantation trips, and are merely indications of a day's work.

Poepoe: This term is used on a few plantations to apply to a hilling-up of the cane. It is an Hawaiian term meaning to "round" out, or "circular." It is usually done by pick or hoe. Seventy-five lines is a good day's work.

Cane Tops for Stables: On the unirrigated places, with Yellow Caledonia cane, it is very easy to get good cane tops, and one man may supply enough for 100 animals. On an irrigated place, however, with other varieties, one man often can only cut enough for 50 animals. As in seed cutting, there is a knack in this job, and one man having it could not be replaced with three men.

Most of the other topics under "Miscellaneous" are self-explanatory, and are what have been done under certain conditions.

Fuel Economy in the Cane Sugar Factory*

By G. H. W. Barnhart

The subjects of Fuel Economy, Fireroom Efficiency, and Heat Conservation have been well covered in previous papers before this and other Associations, and the writer feels that further discussion of these subjects would be a needless repetition. However, there are some points which came up at the meeting last year, also some queries this year, which have prompted the presentation of the following relative to economical size of mill engines, choice of mill electrical power plant equipment, quantity of boiler heating surface for an economical utilization of the bagasse produced, economizers, presence of carbon monoxide in flue gases, insulation of hot piping in the factory, sizes of steam lines, "extra steam" and filter pressing, which may be of interest.

The general rule for power required in an engine driving a two-roll crusher is fifteen indicated horsepower per ton of fiber ground per hour; thirty per ton fiber ground in a three-roller crusher; and thirty per ton fiber hour for each three-roller mill in a train. This includes power necessary in operating juice strainers and cush-cush elevators, bagasse elevators and other equipment incident to a mill. It is further based on an hydraulic pressure of 75 to 80 tons per lineal foot of top roller. The grouping of crusher and mills with reference to engine drive varies with the installation and designer. The arrangement being known, the power required in the respective engines is readily computed. The choice of speed for crusher or mill engines depends on two considerations. A slow speed involving a minimum of reduction gearing necessitates a very large engine. A high speed with a large gear ratio is not desired, mainly because of the fact that breakages are likely to occur and it is necessary to bring the engines to a stop in as short a time as possible. Furthermore, there is a practicable limit to piston speed. In crusher engines a speed of seventy-five is the maximum desirable, while for mill engines sixty to sixty-five has been found to be the practicable limit. The maximum pressure a boiler can carry determines to a great extent the pressure at which the mill engines will operate. A careful study of Corliss engine diagrams and steam consumption data indicates a minimum steam consumption where the mean effective pressure is about forty per cent of throttle pressure. Reference to the accompanying diagram will indicate to what extent the steam consumption increases or decreases as the mean effective pressure varies from this figure. For a factory grinding fifty tons of cane per hour with a throttle pressure of one hundred and fifteen and a back pressure of five pounds the difference in consumption could readily be fourteen hundred pounds per hour equivalent to two per cent of the bagasse. In an extreme case where the pressure is double the optimum, as where an engine operates just short of the point where it would take steam "full stroke," the extra consumption would be equivalent to nine per cent of the bagasse.

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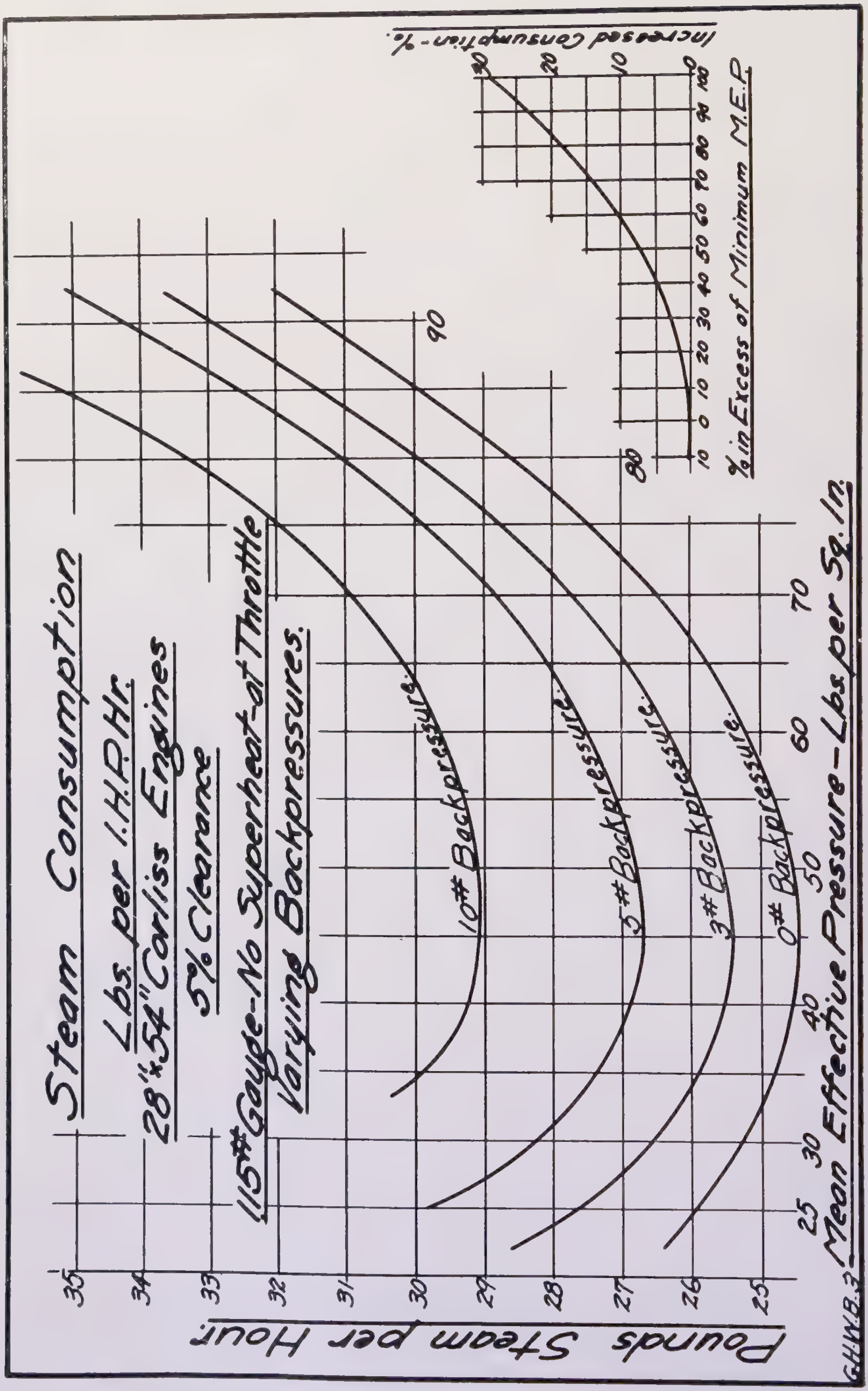
* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

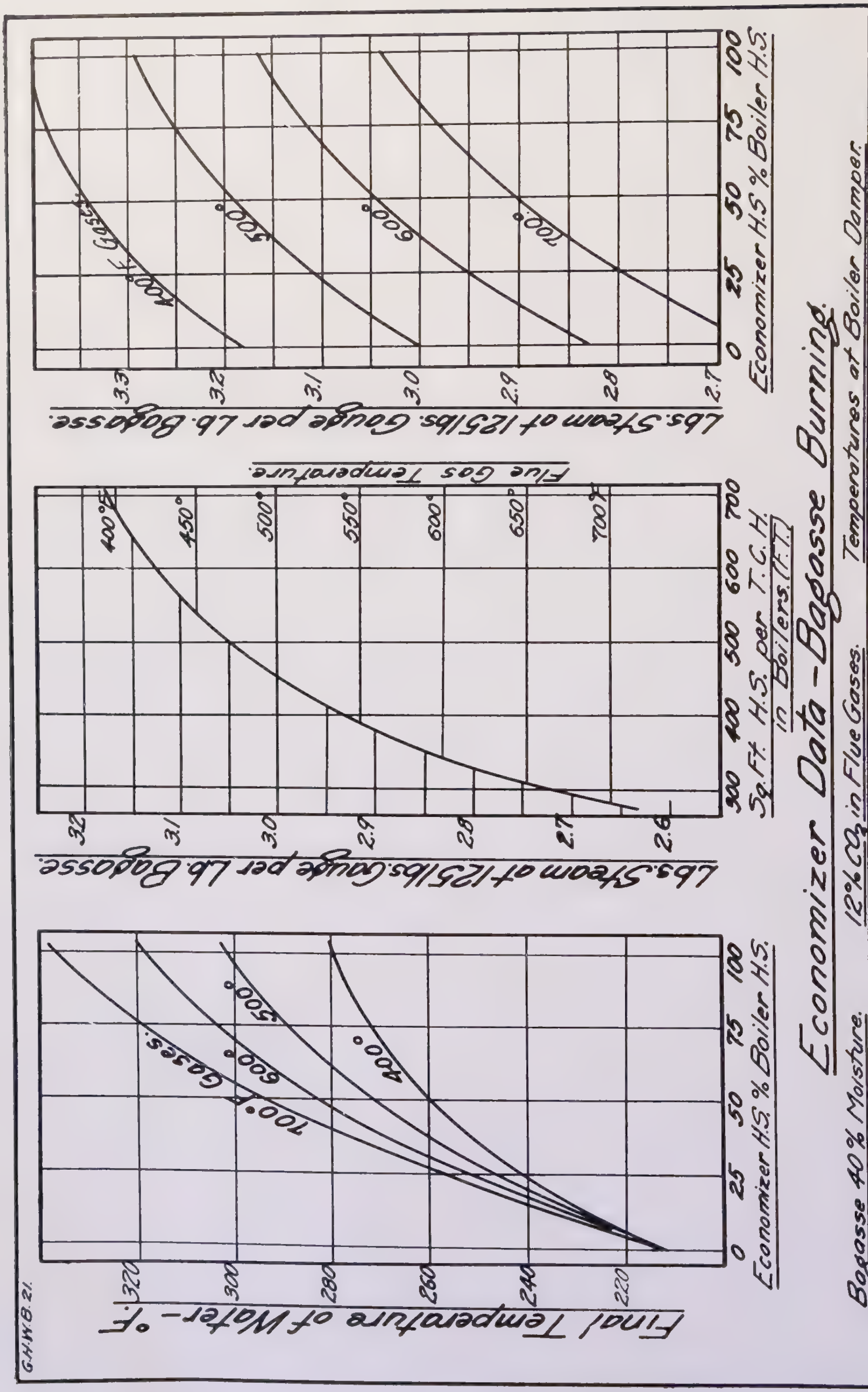

Steam Consumption
Lbs. per I.H.P.Hr.
28"×54" Corliss Engines
5% Clearance
115# Gauge—No Superheat at Throttle
Varying Backpressures.
10# Backpressure.
5# Backpressure.
3# Backpressure.
0# Backpressure.
Mean Effective Pressure—Lbs. per Sq. In.
Pounds Steam per Hour
% in Excess of Minimum M.E.P.
Increased Consumption - %.
25 30 40 50 60 70 80 90
35 34 33 32 31 30 29 28 27 26 25
10 0 10 20 30 40 50 60 70 80 90 100
0 10 20 30
G.H.W.B.3

The ideal arrangement for a mill power plant where much outside power is supplied is a non-condensing turbo-generator running in parallel with a condensing unit, the former to be controlled by a back pressure regulator which controls the load on it so that the pressure in the exhaust lines will be maintained at a constant predetermined point. By this arrangement there will be no serious perturbations in the back-pressure system, the quantity of exhaust steam being always equal to the demand by evaporator, pans, and heaters, no live steam being used in these apparatus, the condensing load being maintained at a minimum. The size of non-condensing unit depends entirely on the extent to which the principle of "extra steam" is applied in the factory. The size of condensing unit will depend on this, and in addition the outside load to be carried. A fair estimate of the requirements can be made in each case, but it must be remembered that the demand for exhaust steam varies considerably according to the fluctuations in the boiling house and each unit must be designed for this variation. However, the extreme peak load in the case of the non-condensing unit occurs but a very small part of the time and can possibly be neglected, as electrical equipment of this type is designed to carry definite overloads for short intervals without harm. The next consideration is the steam rate of the unit. Whereas in central power stations most units are purchased on a basis of full load efficiency and operation is so controlled that only the most efficient machines are delivering power, in the case of a cane sugar factory each of the machines mentioned should be purchased on a basis of average efficiency over the ranges indicated. It will be appreciated at this point that for a given exhaust steam demand, for every kilowatt additional that the non-condensing unit can carry, due to a lower steam rate, the load on the condensing unit is reduced accordingly and a corresponding saving made in bagasse or in the extra fuel bill.

Standard practice indicates a boiler heating surface of 450 square feet in fire tube boilers for each ton of cane ground per hour. This corresponds to 375 square feet in water tube boilers. Both take into consideration the heating surface which may be out of commission for cleaning, etc. Assuming that a boiler operates at rating with flue gases at 500° F., then with other conditions favorable the increase in flue gas temperature will increase the mean temperature difference and the rating in proportion. The ratings and other data will then be:

Temperature Flue Gases	Square Feet Heating Surface Fire Tube	Square Feet Heating Surface Water Tube	Per Cent of Heating Surface	Boiler Rating Per Cent	Pounds Steam From 212° F. to Steam at 125 Lbs. Gauge
700° F.	283	236	62.9	135.0	2.66
650	312	260	69.2	127.2	2.74
600	353	294	78.5	119.0	2.83
550	395	329	87.8	109.6	2.91
500	450	375	100.0	100.0	3.00
450	530	442	117.9	87.2	3.09
400	676	563	150.1	71.8	3.18

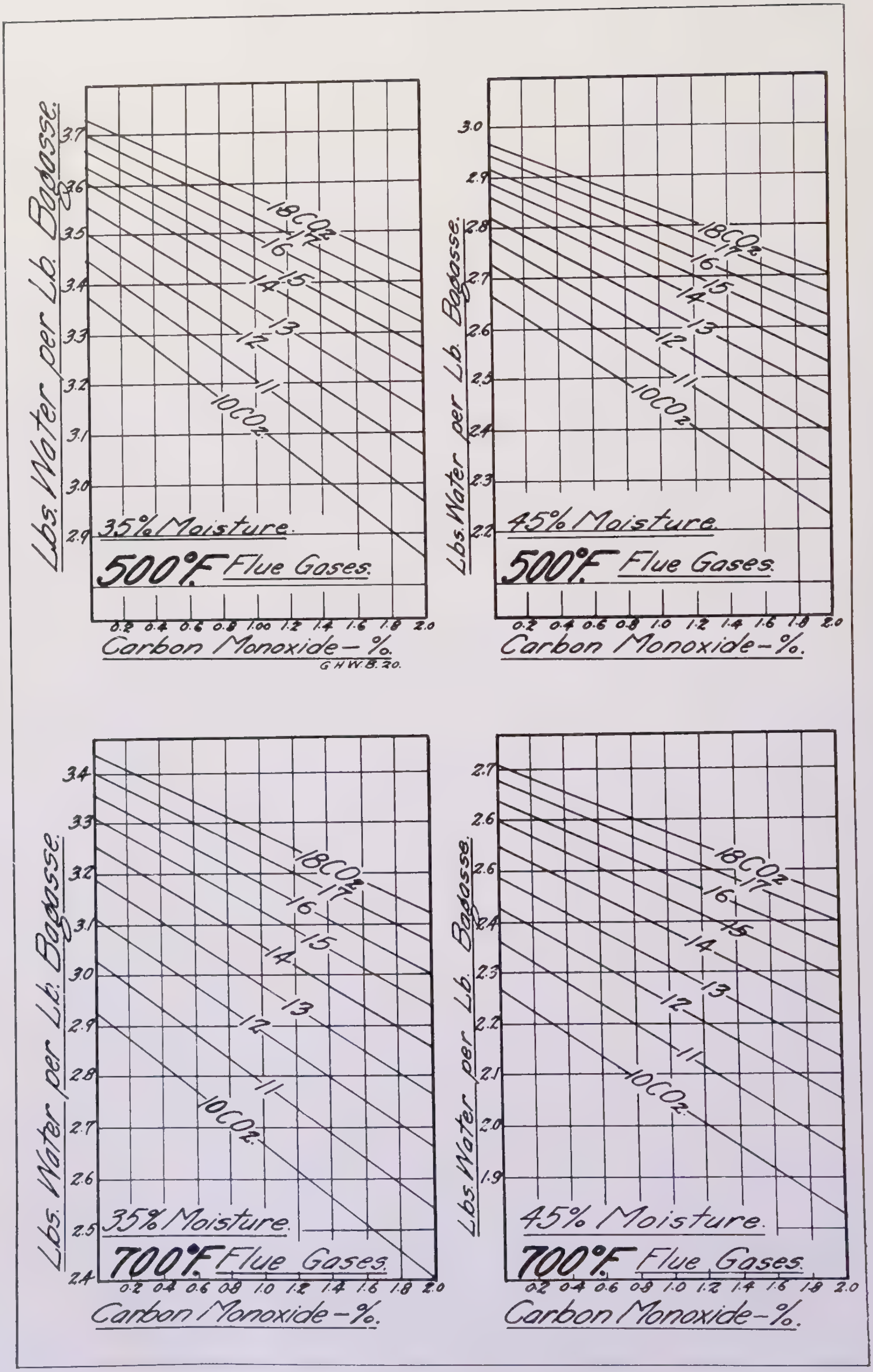
Evidently an increase in rating by raising the flue gas temperature is at a sacrifice in efficiency unless the heat lost can be regained by means of economizers. The accompanying diagram indicates the rise in temperature in boiler feed water from an initial temperature of 212° F. with economizer surfaces installed


Economizer Data - Bagasse Burning.
Bagasse 40% Moisture.
12% CO_2 in Flue Gases.
Temperatures at Boiler Damper.
Final Temperature of Water - °F.
320 300 280 260 240 220
Economizer H.S. % Boiler H.S.
0 25 50 75 100
700° F. Gases.
600°
500°
400°
Lbs. Steam at 125 lbs. Gauge per Lb. Bagasse.
3.2 3.1 3.0 2.9 2.8 2.7 2.6
Sq. Ft. H.S. per T.C.H. in Boilers (F.T.)
300 400 500 600 700
Flue Gas Temperature.
400°F. 450° 500° 550° 600° 650° 700°F.
Lbs. Steam at 125 lbs. Gauge per Lb. Bagasse.
3.3 3.2 3.1 3.0 2.9 2.8 2.7
Economizer H.S. % Boiler H.S.
0 25 50 75 100
400° F. Gases.
500°
600°
700°
G.H.W.B. 21.

between the boilers and stack. The central diagram indicates evaporation per pound of bagasse for corresponding flue gas temperatures and heating surfaces, while the diagram on the right gives the evaporation per pound of bagasse with varying combinations of boiler and economizer surface. To obtain, for example, three pounds of steam from each pound of bagasse three combinations are possible, viz., 450 square feet of heating surface in fire tube (375 in water tube) boilers per ton of cane ground per hour; 353 square feet of fire tube surface and 131 square feet (37 per cent) of economizer surface; or 283 square feet of fire tube surface and 232 square feet (82 per cent) of economizer surface. Recent prices covering boiler and economizer installations indicate a price of \$3.50 per square foot for economizer surface installed and \$3.25 per square foot for boiler surface installed. A comparison of these and other combinations indicates that for equal costs an all-boiler installation will invariably show a better economy than a combination of boiler and economizer. This is of particular interest since operation of an economizer under bagasse burning conditions entails difficulties due to the high moisture content of the heated vapors and a continually lowering heat transmission rate due to the accumulation of particles of bagasse carbon in spite of mechanical scrapers. These particles of bagasse carbon have been described as excellent material for insulating purposes and their accumulation on the tubes of the economizer undoubtedly reduces its efficiency considerably.

In general, bagasse may be said to be burned with a high degree of efficiency if the percentage of CO_2 is from 12 to 14 and the flue gas temperature from 500° F. to 600° F. The writer has gained the impression that those in charge of boiler room operation are inclined to admit too much excess air to their furnaces in order to prevent the formation of any carbon monoxide. This term has been stressed to the point that it would appear to be the "unpardonable sin" of boiler room operation to have CO detected in one's flue gases. Reference to the accompanying set of diagrams will indicate to what extent CO may be tolerated in flue gases. If 12 per cent CO_2 seems to be the safe upper limit for flue gases without CO, then with gases at 500° F. and moisture per cent bagasse at 35 the evaporation F/A 212° F. is 3.5 pounds per pound of bagasse. Then if the CO does not increase above 0.26, 0.54, 0.73, 0.94, 1.20 or 1.46 per cent respectively as the CO_2 is increased to 13, 14, 15, 16, 17 or 18 per cent, just as good work is being done in evaporation. The four diagrams given will supply all information required covering the usual range of fireroom practice. Some of the advantages resulting from decreasing the excess air are decreased load on the stack, a hotter furnace, a higher boiler rating, and a lower flue gas temperature.

Measurements of piping indicate 287 square feet of radiating surface on an average for each ton of cane ground per hour. Of this 189 square feet, or 66 per cent was due to live and exhaust steam piping. Evaporation from bare pipe would be equivalent to 12.64 per cent of the total bagasse produced, while with 1″ Magnesia covering it would be reduced to 1.61 per cent, and with 1.5″ covering it would be reduced to 1.46 per cent. The writer has in mind several factories where, on account of insufficient, poor, or no insulation on the return piping, the temperature of condensate is or has been as low as 160° F. In one instance where attention has been given to this detail the average temperature of the


Lbs. Water per Lb. Bagasse.
35% Moisture.
500°F. Flue Gases.
18 CO2
17
16
15
14
13
12
11
10 CO2
Carbon Monoxide – %.
G.H.W.B. 20.
45% Moisture.
500°F. Flue Gases.
35% Moisture.
700°F. Flue Gases.
45% Moisture.
700°F. Flue Gases.

return has been increased to 210-212° F. resulting in a saving of slightly over five per cent, each ten degree rise being roughly equivalent to a one per cent saving. A further saving, not so easily measured, can be accomplished by the insulation of all steam cylinders, traps, hot juice and syrup lines, heaters, pans, evaporators, settling tanks, and other hot surfaces. The indirect gain will be a cooler factory and more contented operators. The electrification of cane sugar factory equipment as practiced in Hawaii should reduce the radiation surfaces due to live and exhaust steam piping by fully one-half, while careful consideration of the arrangement and location of the various apparatus should account for a further reduction in the quantity of piping.

The proper size for a steam line is generally a compromise between a small pipe necessitating a high velocity and large pressure drop, and a large line occasioning a less velocity and smaller drop in pressure but accompanied by a high radiation loss. A drop in pressure caused by friction is not a loss of energy because the energy reappears as heat. If the steam entering the line is wet, this heat tends to evaporate the moisture in the steam. If the steam is initially dry, the heat tends to superheat it, or if initially superheated, to add to the superheat. The equipment to which the steam is delivered determines whether this heat gained at the expense of a drop in pressure, is utilized or wasted. In general the boilers, the steam lines, and the steam consumers are dependent, each on the other, and all should be considered in the determination of the size of steam line, and the economical size of line is such that the cost of fuel required to generate steam for the operation of the equipment, plus the fixed charges and maintenance on the line, are a minimum.

The extra use of steam—contracted in general usage to "extra steam"—has been discussed frequently as a means of conservation of fuel both in cane and beet factories. In the former the use of double, triple, quadruple and even quintuple effects marks the first step in this process. The use of pre-evaporators supplying vapors for all heating is the second step and will accomplish a seven per cent saving in steam in a factory now applying the "extra steam" principle only in so far as it uses a quadruple effect. Further applications of this principle, which will not be mentioned here, are in common use in beet factories and may effect up to a 31 per cent saving in steam on quadruple effect evaporation alone. The recently advocated pressure evaporation as described by Mr. Terry probably will not find much, if any, application in cane factories owing to dissimilar conditions. The steam compressor, while of advantage in a factory which lacks sufficient heating surface in evaporator or pans, is not an ideal apparatus since it requires live steam in the ratio of about one to one to "boost" the pressure. Where there are no outside power requirements this apparatus is of advantage, particularly where live steam is ordinarily used to make up a deficiency in exhaust steam. It is probable also that it would be used only in the final stages of boiling when the total live steam consumption would be slight.

Fuel economy may be effected at the heater station by the use of well insulated, baffled, heaters while the use of a comparatively high back pressure in the factory will result in a minimum of heating surface with a corresponding reduction in loss by radiation.

Recent developments indicate that the Hawaiian standard of seventy-two cubic feet of settling capacity per ton of cane ground per hour is insufficient. Juices with less than 0.02 per cent phosphoric acid do not settle well even with an excess of lime or capacity. Those with 0.03 to 0.04 per cent phosphoric when limed to phenol alkalinity will settle and leave a limpid juice with somewhat more than seventy-two cubic feet, while those with more than 0.05 per cent phosphoric acid require well over a hundred and ten cubic feet. This increase in settling capacity naturally increases the radiating surface in tanks. For practical reasons it is advisable to have from six to eight settling tanks at this station. The very slight increase in settling time due to a greater number of smaller tanks is not warranted by the increased expenditure or increased attendance necessary. Furthermore, the smaller number of larger tanks involved a smaller radiating surface which should be insulated to the practicable limit.

Pre-evaporators, vacuum pans, evaporators, and juice heaters, have heating surfaces, and correspondingly large bodies, which vary inversely as certain functions of the steam pressure in the boiling house. As this pressure is increased either the rate of work is increased, or the size of apparatus can be decreased for a given amount of work. At the same time the steam lines supplying these apparatus can be reduced in size. Each of these apparatus and also the steam lines to them should be properly insulated.

A large amount of heat is lost at the filter press station on account of the long cycle involved. An added loss is that due to the prolonged washing which adds to the amount of work at the evaporator station. The Kopke separator is the only means the writer knows of whereby the cycle can be shortened and the quantity of water lessened. This equipment has been given a partial trial during the past season and has demonstrated its possibilities so well that centrifugal separation of settlings will be given a thorough trial on a factory scale during the coming year. A consideration from the standpoint of fuel economy would involve a comparison of power required to drive the centrifugals together with the slight radiation loss, with the extra quantity of wash water to be evaporated together with the large radiation loss and loss by inversion of sucrose in the case of filter presses.

Four factors, probably, have contributed to the gradual increase in heating surface required in pans, evaporators and heaters in the cane sugar factory. These are: (1) An increase in the grinding rate, which is a natural result of an increase in acreage, of intensified agriculture, of the aim of the operating force to take off crops during periods which will net the greatest returns to the plantation, and of car shortage. (2) An increase in power requirements, due to the introduction of the Messchaert groove, which, eliminating practically all feeding difficulties, has enabled "setting-up" rollers and increasing the hydraulic pressures carried. (3) A decrease in the operating pressure possible in some factories, due to the limitations of lap-seam boilers and to age in other boilers; and (4) The introduction of the calandria type of vacuum pan, permitting faster boiling, and the substitution of exhaust steam in the calandria for live steam in the coils, which has lead to increasing the ratio of heating surface to capacity from 1 to 2 to 1.2 to 1 and in some cases 2 to 1. The net result of the first three items

has been an increase in the quantity of exhaust steam produced. Back pressures have increased gradually, and where sufficient evaporator surface has permitted, evaporation of syrup to a higher density has been practiced. Water added per cent cane has gradually increased and the evaporation of this has helped reduce the surplus exhaust. Unable or unwilling to purchase and install boilers for higher operating pressures or to install more economical mill engines, the only remaining expedient of increasing the heating surfaces in pans, evaporators and heaters and of burning extra fuel when and where necessary, has been resorted to.

This procedure, the writer feels, is an incorrect and uneconomical one. The installation of an additional pan, a heater, and sometimes the substitution of a larger evaporator, should not be made as a means of reducing exhaust pressure, as this will not be accomplished, unless at the same time, more liquor from which evaporation can take place, is introduced into process. Provided the heating surfaces permit, an actual saving in fuel will be made if the blow-off is set to operate at a lower pressure and the surplus exhaust wasted. The logical procedure in practically all of these difficulties is to replace prime movers which are uneconomical of steam, with apparatus having lower steam rates, or better still to install the more economical apparatus in the first instance, and a surplus of bagasse, indicating that extra fuel is no longer needed, will be the direct result.

Cultivation and Weed Control*

By W. L. S. Williams

For some years, the opinion has been gaining strength that the main purpose of cultivation is the control of weeds. Aeration and loosening of the soil, and drainage, or the conservation of soil moisture, as reasons for cultivating the land, are coming to be looked upon as secondary in importance, except in the case of plowing and preparing land for planting. This opinion is borne out by the results of cultivation experiments carried on by the Experiment Station, H. S. P. A., a tabulation of which is given in the *Hawaiian Planters' Record* for July, 1924. This series of experiments, covering both irrigated and unirrigated plantations, from Kauai to Hawaii, shows that an average loss of 0.2 ton of sugar per acre was recorded from all plots where plows were used, as compared with plots where weeds were controlled by hoes and light cultivators. Similar results have been obtained by the U. S. Department of Agriculture working with corn, no increase in yield being obtained from deep cultivation, as against the omission of the practice, so long as weeds were kept out of the crop in both cases. Quoting Mr. Verret: "This shows that, for average conditions, deep cultivation with plows in growing cane cannot be expected to raise the yield of sugar in itself. The benefits obtained come through weed control."

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The widely varying conditions on the plantations in these Islands give us all our individual problems in weed control. In the irrigated districts, part of the problem will be in keeping weed seeds out of the irrigation water, while weeds which come up in the cane must be controlled by hoeing, the use of animals in lines laid out for irrigation being practically impossible. With the new system of overhead irrigation now coming into use, cane is planted in straight lines, and animals can be employed. In the drier, unirrigated districts, weed control and the conservation of soil moisture are intimately associated. In the very wet districts, drainage is secondary only to the control of weeds.

With the ordinary operations, burning, palipali-ing, off-barring, hoeing, cultivating, small plowing, hilling, weeding, and stripping, we are all familiar. Paper mulching and arsenic spraying are methods of weed control not in such common use. Combinations of some or all of these operations are used on all plantations, the routine combination for any given place being the outgrowth of experience in meeting the conditions obtaining on that plantation. In general, the combinations of operations used fall into the three classes of: irrigated lands, where weeds are controlled by hand labor; unirrigated dry lands, where weeds in the cane row are controlled by hoeing, the centers between the lines being kept clean by animals with light implements after off-barring; and, unirrigated wet lands, where weeds in the cane row are controlled by hoeing, hand weeding, and sometimes paper mulching, while the weeds between the rows are kept down by animal cultivation with plows alternating with lighter implements, some hand labor hilling-up, and sometimes arsenic spraying.

On irrigated lands, where animals are rarely used for cultivating in the growing cane, the problem of disturbing the cane roots is not encountered. On the unirrigated plantations, however, this is not the case. The use of plows in weed control on unirrigated lands can scarcely be avoided, unless paper mulching and arsenic spraying are resorted to. We find that we must off-bar in order to have loose soil for light implements to work in on the drier lands, while in wet districts we must not only off-bar, but split the centers of the rows and hill-up afterwards to get rid of the heavy growth of weeds between the lines. For unirrigated plantations, it is, then, necessary to get the off-barring done as early as possible, preferably immediately after burning off, before many roots have formed. After early off-barring, particularly in dry weather, damage may be done to the stools by drying out, so it is usually good policy to follow off-barring by light cultivators to push the loosened soil back against the stools. In dry districts, weeds in the kuakua can subsequently be controlled by alternate cultivations with Horner harrows and Planet Jr. cultivators. In wet districts, where plows must be used in conjunction with lighter implements, the earlier the plowing and hilling-up are done, the less damage will be suffered by the cane roots. It has been found unnecessary to wait for the cane to close in before hilling-up where the cane has a vigorous growth.

It is interesting to note how the combinations of operations in use on the dry and wet lands conform to the secondary considerations of conservation of soil moisture and drainage. In the dry lands, the fields are left practically level, thus exposing the least surface to the drying action of sun and wind. In the wet dis-

tricts, the cane is left on the ridges with shallow furrows between, which help to drain off excess water, and allow some of the roots to get air, even in long continued periods of rainfall.

In the foregoing, nothing has been said about replanting. In the end, it is the cane itself which controls the weeds in our fields. All we have to do is to give it a start and get it closed in. This cannot be done unless we have a full stand of cane, which in turn depends on keeping our sled and wagon roads, flume and portable track lines, and all other blanks filled up from crop to crop. In the wet districts, transplanting stools for small blanks, and planting up larger areas with seed is the practice. In dry districts, stool transplanting cannot be practiced successfully, and filling small blanks with seed is unsatisfactory unless done very early.

Before closing this brief paper, mention should be made of three or four practices which will be taken up more fully in the discussion to follow. Splitting lines in place of regular round plowing, as preparation for planting has been used quite extensively for the past few years. Puka planting, in place of planting in lines, is coming up in connection with work in bud selection. Soaking of cane seed in a dilute solution of nitrate of soda has been suggested as a method of speeding up germination, and increasing the growth of young plant cane. Stripping, not with regard to its benefits to the crop on the ground, but as it affects the control of weeds in the following crop, is again a subject for discussion.

Our mills have reached the point where improvements are noted in fractions of one per cent, but records are still being broken in the production of sugar per acre. When yields run from two tons up to the record of eighteen tons of sugar per acre, with the average for the Territory at less than six tons, it is evident that the possibility of increasing our average yield of sugar per acre by fifty per cent is by no means hopeless. It is through intensive cultivation, and the raising of our standards in the field, that the sugar industry in Hawaii must hold its own.

Notes on P_2O_5 and K_2O Determinations in Crusher Juice at Pioneer Mill Company*

By J. H. Pratt

This work was continued during the 1924 crop as part of the regular laboratory routine. To date we have a total of 1,518 P_2O_5 and 1,426 K_2O determinations (not counting special samples) and have taken samples from 136 out of 147 fields. Five of the remaining eleven fields will be harvested in 1925, so that the plantation will be pretty thoroughly covered.

A comparison of the averages for the three crops is shown in Table 1. As a rule the K_2O was lower in 1924 than it was in 1923. No reason for this is

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known, but it is probably a seasonal variation. The P_2O_5 averages, however, seem to check closely. There is a narrow strip, consisting of Fields E 3, F 4, G 3 and 4, H 4, and I 4, which is much lower in K_2O than the adjoining fields, especially at the makai end. In both years, the fields on the Kaanapali side of this strip were found to be lower in both K_2O and P_2O_5 than were those on the Lahaina side of the strip. This accounts for the averages of "G" and "H" being higher in 1924 and "I" being lower. The P_2O_5 is higher in Fields LD, MD and O in 1924 than it was in 1923 and 1922. This, I think, is due to errors in analysis. During the past year, quite a number of samples from these fields were found to give a "false end point." This was not noticed in 1923, except in the case of Yellow Caledonia cane from Olaa, in which it was very marked.

The plant cane is again lower than the ratoons from the same or adjoining fields and in about the same proportion as in 1923:

P_2O_5,	higher in 28 out of 38 comparisons;	average difference 19.84%
P_2O_5/100 Brix,	higher in 26 out of 38 comparisons;	average difference 17.63%
K_2O,	higher in 24 out of 37 comparisons;	average difference 15.07%
K_2O/100 Brix,	higher in 25 out of 37 comparisons;	average difference 14.73%

The short ratoons are again higher than the long ratoons in P_2O_5, being higher in 70 per cent of the comparisons. The average difference is 9 per cent. They are about the same in K_2O.

As very few of the groups of fields were harvested during every month of the crop, it is rather difficult to compare the effect of the time of cutting on the P_2O_5 and K_2O. After considerable experimenting a fairly simple method was invented, which also has the advantage of making allowance for the number of samples taken during the various months. The K_2O shows a steady decrease from December to the end of the crop for both crops. The only exception to this rule is April, 1924. The P_2O_5 shows an increase to a peak in February and then a gradual falling off to the close of the crop. This is also true for both years, except for March and April, 1924.

The effect of the variety of cane on the P_2O_5 and K_2O in the juice is about the same as reported in 1923. Based on comparisons of fields and not on a few sticks or stools, H 109 seems to take less P_2O_5 and K_2O from the soil than any other variety. In 18 comparisons, Striped Mexican is 2 per cent higher in P_2O_5 and 11 per cent higher in K_2O. Lahaina is 8 per cent higher in P_2O_5, but 3 per cent lower in K_2O in 11 comparisons. D 1135 is even higher, in 10 comparisons, it had 12 per cent more P_2O_5 and 32 per cent more K_2O than H 109. Judging from one comparison and from several analyses of a few sticks, Yellow Caledonia takes more P_2O_5 from the soil than any of these four varieties.

As in 1923, there is no direct relationship between the P_2O_5 or K_2O and either the tons of cane or sugar per acre. The average of the fields yielding a juice low in P_2O_5 or K_2O shows less cane to the acre and a much better quality ratio than in the average of the fields which are higher in these ingredients. The "TC/TS" for the crop are:

	P_2O_5	K_2O
High fields	8.58	8.33
Good fields	8.26	8.05
Intermediate fields	....	7.37
Fair fields	7.50	7.25
Low fields	7.04	7.05

This is interesting, although how much of it may be due to the P_2O_5 and K_2O is rather problematical. The "high" fields, for instance, have practically all the short ratoons, they have more tons of cane to the acre, and they get a much larger proportion of pump water. On the other hand, they were cut near the close of the crop when the juice was better than it had been previously.

The relative amounts of cane with varying amounts of P_2O_5 for the last two crops are shown by the following figures:

P_2O_5 per	Approximate	Crop of 1923		Crop of 1924	
100 Brix	Per cent P_2O_5	Tons Cane	Per cent	Tons Cane	Per cent
.000–.050	.00–.01	37,084.802	16.70	65,701.084	25.11
.050–.100	.01–.02	99,107.272	44.64	78,556.247	30.02
.100–.150	.02–.03	39,662.662	17.87	49,808.299	19.03
.150–.200	.03–.04	23,198.764	10.45	23,781.407	9.09
.200–.250	.04–.05	6,577.551	2.96	21,314.663	8.14
.250–.300	.05–.06	16,387.640	7.38	17,391.013	6.65
.300–.350	.06–.07	....	....	5,117.629	1.96
Totals..................		222,018.691	100.00	261,670.342	100.00
Average P_2O_5 per 100 Brix		.1013		.1144	

The amount of P_2O_5 necessary in mixed juice for a good clarification is from .035 to .04, which is equivalent to from .047 to .053 per cent in crusher juice. It is interesting to note that less than 10 per cent of our cane has this amount.

TABLE 1

Number of Samples and Per cent (per 100 Brix)

	P_2O_5								K_2O					
	1922		1923		1924		Average		1923		1924		Average	
Field	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
A	6	0.666	4	0.028	36	0.054	46	0.053	4	0.827	36	0.548	40	0.576
B	14	0.095	46	0.063	81	0.067	141	0.068½	50	0.902	80	0.507	130	0.659
C	5	0.130	32	0.113	42	0.117	79	0.116	29	2.055	41	1.622	70	1.801
D	.	....	23	0.214	44	0.218	67	0.217	19	1.679	42	1.574	61	1.607
E	3	0.057	12	0.052½	17	0.062	32	0.058	12	0.798	18	0.650	30	0.709
F	3	0.058	27	0.052	34	0.055	64	0.054	28	0.789	34	0.510	62	0.641
G ...	2	0.060	16	0.057	30	0.084	48	0.074	17	0.562	29	0.550	46	0.554
H ...	3	0.105	26	0.097	113	0.122	142	0.116	25	1.640	111	1.520	136	1.542
I	9	0.206	5	0.222	46	0.149	60	0.164	6	1.864	45	1.567	51	1.602
LA ..	.	....	31	0.066	..	....	31	0.066	31	0.684	..	....	31	0.684
LB ..	2	0.116	37	0.113	10	0.118	49	0.114	36	0.875	10	0.566	46	0.808
LC ..	.	....	48	0.191	16	0.218	64	0.198	46	1.494	16	1.610	62	1.524
LD ..	.	....	24	0.188	15	0.237	39	0.207	23	1.774	15	1.696	38	1.743
O	5	0.232	50	0.233	124	0.264	179	0.254	48	1.840	124	1.860	172	1.854
MA ..	6	0.074	..	....	53	0.088	59	0.086	..	....	53	0.729	53	0.729
MB ..	.	....	13	0.115	67	0.103	80	0.105	13	1.002	65	0.961	78	0.968
MC ..	4	0.239	6	0.178	75	0.169	85	0.173	5	1.767	76	1.470	81	1.488
MD ..	4	0.214	4	0.204	110	0.271	118	0.267	4	2.032	109	1.776	113	1.784
30–34	3	0.065	48	0.049	37	0.046	88	0.048	46	1.288	37	0.728	83	1.050
	2	0.100	16	0.076	29	0.123	47	0.108	16	0.695	27	1.004	43	0.889
Ave.	71	0.128	468	0.121	979	0.152	1518	0.141	458	1.286	968	1.267	1426	1.273

True Averages (based on the tons of cane), P_2O_5 per 100 Brix

	Plant	Long Ratoons	Short Ratoons	Average
1924 Crop..........................	.0664	.1286	.2277	.1144
1923 Crop..........................	.0622	.1062	.2289	.1013

Clarification*

By W. R. McAllep

The results of our previous investigations have been discussed thoroughly enough at these meetings and during factory inspections so that it seems hardly necessary to take up in this paper such subjects as obtaining the maximum increase in purity, the bacteriological considerations involved, the effect of cush cush, etc.

Laboratory work at the Experiment Station during the past year on this project has consisted of: (1) Correlating and studying data secured by H. F. Bomonti on the characteristics of hot clarified juices. (2) Further investigations by H. A. Cook on points developed by Mr. Bomonti's work. (3) Work by Mr. Cook on developing adequate and practicable means for controlling the clarification.

The work by Mr. Bomonti, which has been published in the October *Record*, was undertaken to obtain definite information based on direct experiment on the changes taking place in juice while it is held at high temperatures, that is, from the time it passes through the heaters until lower temperatures are encountered in the evaporators. Comments have been made previously on portions of this work, it having been pointed out that inversion of sucrose was definitely demonstrated in slightly alkaline juices but could not be detected at higher alkalinities. Also that though glucose was destroyed during clarification at alkaline reactions, further destruction was not detected during the digestion of the juice at high temperatures.

On compiling and studying data as a whole, the indications are strong, that from a practical standpoint, one of the most important factors with which we have to deal in factory operation is development of acidity, particularly that taking place at temperatures too high for the development of bacteria.

The term development of acidity is here used to designate a change in the direction alkaline to acid. In addition to development of acidity due to bacterial action, development of acidity takes place in two ways which bear little relation to each other. One is an increase in the total amount of products of an acid nature. The other is an increase in the activity of the acid. The following comments refer to juices not more alkaline than a slight alkalinity to phenolphtha-

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lein, which reaction we consider about as alkaline as is at all practicable in raw cane sugar factories.

In these experiments increase in the amount of acid products was measured by titration with phenolphthalein and litmus. On the basis of phenolphthalein titration, increases in the quantity of acid products proceeded at about the same velocity in alkaline and acid juices. On the basis of litmus titration, there was somewhat of a tendency for it to proceed more rapidly in the more alkaline juices. With both indicators increase in the quantity of acid products took place much more rapidly as temperatures were increased.

Acid acts as a catalyzer in the hydrolysis of sucrose; that is, it causes inversion of sucrose without being consumed. The activity of acid, in other words the hydrogen ion concentration, is therefore of much greater importance in sugar factory practice than the quantity. On the basis of activity, development of acidity at a given temperature proceeds very slowly in the more alkaline juices. In the more acid juices, development of acidity is many times as fast. Also on the basis of activity the development of acidity becomes much faster as temperatures are increased.

It has been the general opinion in factory practice, that alkaline juices become acid faster than the acid juices. Perhaps this is partly due to the fact that litmus has been the indicator commonly used. In the light of data secured during this investigation, this theory is quite contrary to the actual facts, at least so far as the really significant factor, hydrogen ion concentration, is concerned, and within the range of reactions practicable in sugar factory operation.

We have little information on the nature of development of acidity further than that it is a factor of time, temperature, and reaction of the juice. It has been ascribed to the destructive action of lime on glucose, but available data strongly indicate that this cannot be a major factor. It has been noted in the canning industry, where no alkali has been added. It is probably a characteristic of most, if not all, plant juices. Oils also show a similar characteristic, this being particularly noticeable in steam turbine operation.

These data positively indicating inversion of sucrose in slightly alkaline juices, make it appear most probable that inversion in juices proceeds approximately in proportion to the hydrogen ion concentration. Inversion in slightly alkaline juices is not at all inconsistent with our modern conceptions of acidity, neutrality and alkalinity. Neutrality means that hydrogen and hydroxyl ions are present in equal concentrations, not the absence of disassociated ions. In passing from neutrality to alkalinity, that is, from 7 to higher pH values, hydroxyl ions increase with a corresponding decrease in hydrogen ions, the product of the two remaining constant. Thus hydrogen ions are still present even in alkaline solutions, though in greatly reduced quantity. There is little reason to believe that the activity of the remaining hydrogen ions is changed. From this point of view, some inversion would be expected in slightly alkaline juices and indeed it would have been rather surprising had it not been detected.

While destruction of glucose has been noted during the more alkaline clarifications, there has been little, if any, evidence of its further destruction, when the same juices were further digested, at high temperatures.

The above considerations indicate the desirability of as alkaline a clarification as is practicable. While ill effects that might be anticipated from destruction of glucose do not impose a definite limit on the alkalinity, such a limit is imposed by the point at which the maximum increase in purity is secured. This, as a rule, is at about 8.6 pH in the juice after it has passed through the heater. The extent to which development of acidity then takes place is dependent on the temperature and how long the juice is exposed to high temperatures. Under ordinary operating conditions, with the juice leaving the heater at about the above reaction with the temperature approximating the boiling point and the juice not over a couple of hours in the settling tanks, it should leave the latter at from 8.0 to 8.2 pH and the syrup will probably be as alkaline as 7.7 to 7.8. If this is accomplished, any inversion in this part of the process will be absolutely negligible.

This technically desirable procedure cannot be approximated in many cases because of difficulties in filtration due to the large volume of settlings resulting from alkaline clarification and we will not realize the full benefit of our present knowledge of clarification until the problem of filtering a large volume of settlings is solved. However, in such cases we should operate as alkaline as the capacity for filtering settlings will permit, and every effort should be made to obtain maximum efficiency from this equipment.

Mr. Bomonti's work was necessarily planned to give a general idea of what occurs in clarified juices at high temperatures, for little if any exact information was then available on which to base an intensive investigation. Mr. Cook's later work was planned to obtain more precise data on the points that Mr. Bomonti's work developed. From it, we expect to obtain more detailed information on the rate at which acidity develops and the rate at which sucrose is inverted under given hydrogen ion concentration and temperature conditions. More complete data have also been secured at temperatures approximating the boiling point. The results of this more intensive study are in good general agreement with previous work. Evidence of slight destruction of glucose, however, has been found on digesting juices at temperatures approximating the boiling point.

Thorough study and publication of Mr. Cook's data has been temporarily deferred on account of the necessity of developing better means for controlling clarification. Ever since the present clarification investigation was started we have been greatly handicapped because means were not available for definitely expressing the results in terms which could be translated into factory practice. Methods for estimating the hydrogen ion concentrations that are suitable for use in the factory laboratory are greatly needed. The hydrogen electrode, used at this Station is hardly practicable, neither are the usual colorimetric methods using buffer solutions. A colorimetric method has been developed at the Crockett Refinery and operations there are now controlled on this basis. While this is suitable for refinery operations it is not exactly suited to raw sugar factory conditions. In the last few months, Mr. Cook has been working on the necessary modifications. Preparing the color plates required has been a tedious operation, but Mr. Cook has made good progress and we hope to have the method developed so that it can be tried out in factory practice during the coming year. With such a method developed to a satisfactory point, a definite language will be available

for use when clarification or the reaction at which juices should be carried is under discussion.

In the absence of definite means for expressing the results of the investigations in terms that could be translated into factory practice, our original suggestion for approximating what investigation had shown to be desirable clarification practice, was to lime the juice before heating to a pink color with phenolphthalein. The change in reaction in the direction alkaline to acid taking place while the juice is passing through the heater reduces the alkalinity till the reaction of the heated juice is usually within the range where the best results in clarification are secured. This change in reaction varies in different juices. As the really significant factor is the reaction of the juice after heating, the use of phenolphthalein alone does not fully meet the requirements, and some further checks are most desirable. We would now add to our original suggestion the use of two other indicators, thymol blue and cresol red for use in the heated and clarified juice. The juice after passing through the heater should be sufficiently alkaline to give a distinct red with cresol red and a greenish color with thymol blue. It should not be alkaline enough to give a blue color with the latter indicator; at most the color should be a greyish blue. Within this zone the best results in clarification will be obtained. The cresol red will be particularly valuable where the volume of settlings prevents carrying quite this alkalinity. The color change with this indicator passes through orange into yellow as the alkalinity is reduced. We would strongly recommend that when it is impossible to carry the alkalinity at the optimum point, the reaction be maintained alkaline enough so that cresol red gives a distinct orange color in the heated juices.

Since the raw sugar investigation brought out the close relation of good clarification and good refining qualities in the sugar, even more attention than before has been given to applying the results of the clarification investigation during factory inspections, and Mr. Smith has worked toward the same end in factory visits while working on refining qualities of sugar.

Next to insufficient liming, irregular liming has probably been the most serious fault in previous clarification practice. This condition has been greatly improved in the last year or two and now it is quite usual to find the juice fairly even in reaction after going through the heater and mixing in the settling tanks. In many factories, however, different parts of a tank of juice still pass through the heater at widely varying reactions. This condition is objectionable on chemical considerations. Mr. McCleery's observations this year have indicated that it is particularly objectionable from the standpoint of obtaining the clearest juices. His comments on clearness of clarified juice and on this particular phase of the question, based on work during factory inspections follow:

The use of the Kopke turbidimeter has been a great aid in determining what *good* clarification from a physical standpoint really means. This instrument should be used in all our factories and the turbidity figures recorded with the usual routine laboratory data. Larger turbidity figures denote clearer juice than small figures. It is found that if the raw juice and lime are mixed to an even reaction, and if this reaction is at the optimum point demonstrated by our previous work here (faintly alkaline to phenolphthalein, or about 8.8 pH on limed juice before heating), a Kopke turbidity figure of 1.0 can be expected for each .01 per cent P_2O_5 in the mixed juice. In other words with a mixed

juice figure of .035 per cent P_2O_5 and conditions of liming and heating as above, the expected turbidity figure would be about 3.5. Fluming plantations have been found to exceed this figure somewhat. It has been observed that unless the mixed juice and lime milk are thoroughly mixed before heating, the expected clearness of resulting clarified juice is not attained. An efficient means of mixing the juice and lime is essential. Either a compressed air coil, a propeller or set of paddles in the mixing tank under the juice scales will accomplish this. An excellent device for liming and mixing the juice is the one that has been developed at the Oahu Sugar Company. Clarified juice of 3.5 turbidity, usually corresponding to about .035 per cent P_2O_5 in the mixed juice, is clear enough to see through when an ordinary water tumblerful is held toward the light. Mixed juice with more than this amount of phosphoric acid will give clearer juice than the above figure (though with an increased volume of settlings), while mixed juice that is deficient in this respect clarifies poorly, the turbidity decreasing with the increase in phosphoric acid.

On our recommendation, a number of factories having juices low in phosphoric acid, have in a limited way used super-phosphate or double super-phosphate to improve the clearness of the clarified juice. The response to this treatment has been immediate. The use of phosphoric acid compounds in years past had not been particularly successful because of lack of knowledge as to when needed and the quantity. Our work on clarification has included the working out of a phosphoric acid factory control.

Mr. Smith has concluded as a result of his observations that if good efficiency is obtained from filter press equipment and standard filter press capacity is available, it should be possible to lime juices to the optimum point and handle the resulting volume of settlings, provided the phosphoric acid content does not exceed .03 to .04 per cent. Mr. Smith has also concluded after observations at a number of factories that the conditions resulting in clear clarified juice are intimately related if not identical, with the conditions that result in a large volume of settlings. This observation is in excellent agreement with the indications of experimental work.

The Petree Process has now been in use in Hawaii for two seasons. Attempts to appraise the true value of this process are most difficult because of the lack of comparable figures. Adequate treatment of this subject would require detailed analysis of conditions and control figures at each of the factories that is far beyond the scope of a paper such as this. As a result of studies of the Petree Process at each of the factories where it is in opertaion, the writer is of the opinion that notwithstanding the present unsatisfactory state of filtration practice in raw cane sugar factories, the Petree Process cannot compete with the ordinary process when both are properly installed and efficiently operated.

Dr. W. D. Horne's super-defecation process is another patented clarification process that has received considerable attention in the last year or two. The process is now in operation in Cuba. It also is a double settling process, though the juice is not divided as in the Petree Process. The mixed juice is limed to an alkaline reaction, preferably the point giving the largest increase in purity, heated and settled. The settled juice is treated with a phosphate of soda, heated and again settled. This process has some attractive possibilities. Close to the maximum possible increase in purity should be secured and irrespective of the characteristics of the original juice, the clearness of the settled juice can be brought to any desired point, thus securing such advantages as better quality of sugar, less fouling of heating surfaces, etc., that result from securing clear juices. There is an exchange of lime and soda in the ash constituents of the

juice with precipitation of the former. The more soluble sodium salts should have less of a tendency to crystallize out with the sugar, thus reducing the ash and probably the sulphate content of the sugar at a given polarization. Probably, however, this process will be subject to the same difficulty with a large volume of settlings that is encountered in all lime defecation processes when they are operated so that juice of maximum clearness and the maximum increase in purity are secured.

On the whole, filtration is the most serious problem now before us in raw cane sugar factory practice. Our filter presses do not meet technical requirements, nor do they economically separate the soluble from the insoluble in the settlings. Filtration problems, almost, if not quite, as difficult have been satisfactorily solved in other industries, yet no improvement has been made in raw cane sugar factories. Indeed some of our newer presses do not satisfy the requirements in some particulars as satisfactorily as presses the writer had experience with twenty-five years ago. To some extent our lack of progress may be attributed to isolation. To a great extent it is undoubtedly due to failure to fully realize the shortcomings of present equipment in advance of investigations in the last few years.

Kopke centrifugal separators are now being used in an endeavor to solve this problem. As the results secured both in factory practice and in laboratory experiments will be taken up in other papers the writer will not comment further than to say that it is most gratifying to see that serious work is now being done on this problem and that the results should be followed with the greatest interest.

Measurement of Turbidity in Juices*

By Walter E. Smith

In view of the interest in turbidity measurement, some study was made of the various methods available, such as the Kopke turbidimeter, and the observation of carbon lamp filaments, candle flames and cross-lines on translucent paper through a column of liquid in a cylinder. Standard solutions were prepared by coloring distilled water with caramel and adding varying quantities of a kieselguhr suspension.

Ten grams of kieselguhr in 1,000 cc. of distilled water was used as the standard suspension, and varying volumes of this mixture were made up to a volume of 300 cc., together with appropriate volumes of the caramel solution. For convenience, these solutions may be numbered 1, 2, 3 and 4; 1 contained only the kieselguhr suspension and no caramel, while No. 4 approximated the color of the darkest clarified juice ever likely to be encountered.

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

Kopke Turbidimeter

The following results were obtained with the Kopke turbidimeter:

	10 cc. Kieselguhr Suspension in 300 cc.	5 cc. Kieselguhr Suspension in 300 cc.
	cm.	cm.
Solution No. 1 (no color)..........	4.0	6.8
2	3.9	6.7
3	3.8	6.3
4	3.6	6.0

While the effect of color is distinctly noticeable, giving an appreciable difference between the extremes, it seems likely that the difference with the color actually encountered when working with clarified juice would ordinarily be small. The writer has noted cases, however, where the effect of color on turbidity was rather appreciable. With many of the juices found on Kauai, coloring matter present in the juice gives a dark color in alkaline solutions; when such juices are made acid by the addition of a drop or two of acid, there is a very appreciable lightening in color, with a change in turbidity of between 1.0 and 2.0 cm. on the turbidimeter scale.

Nessler Tube Method

A Nessler tube was so arranged that a filament of a light globe could be observed through a column of juice; the cylinder was covered with black paper to exclude outside light. The following results were secured, the figures indicating the number of cubic centimeters of juice in the cylinder at the end point:

Solution No. 1................................	69
2................................	68
3................................	67
4................................	66

The effect of color is not so noticeable as with the Kopke turbidimeter. Considerable fluctuation in the intensity of light, brought about by introducing varying resistance, did not affect the observation to a greater extent than the normal experimental error.

When using a flash light bulb as the light source, the readings obtained were much higher than with the 60-watt lamp, but not so consistent. This was no doubt due to the greater light intensity per unit of filament length.

When cross-lines were ruled on translucent paper, and placed between the light source and the bottom of the cylinder, the results were consistent and capable of accurate duplication, though the readings were much lower than with the direct observation of the lamp filament. Changes in the intensity of the light had little noticeable effect.

Observations of a candle flame under the Nessler tube were indefinite and therefore unsatisfactory. No clear-cut end point could be obtained, thus making the method unsuited to general use for unskilled observers.

In general, methods based on the observation of a lamp filament might be slightly more accurate than the Kopke turbidimeter, though the latter is probably more practicable as a general method to be used under a wide variety of conditions.

Details for Kopke Turbidimeter

Observations should be made close to a window where there is a uniform illumination, away from overhead lighting and never in direct sunlight. Similar results will be obtained through a rather wide variation of lighting conditions.

The turbidimeter should be held so that the tube is vertical, with the plate touching the side of the cylinder nearest the source of light.

The cylinder used should always be clear, as a stained or dirty cylinder will vary the intensity of illumination.

The end point is reached when the cross-lines on the porcelain plate just disappear from sight, but can again be seen by only a slight raising of the plate. At this point, the finger should be placed firmly over the upper end of the tube, so that no solution is allowed to run out.

The cement used on new turbidimeters will quickly loosen; litharge and glycerine mixed to a paste will re-cement the tube and plate together so that they do not come apart, even in hot juice.

For observation at night, a 60- to 75-watt lamp fixed about 18 inches from the cylinder containing the sample, and about 6 to 8 inches above the surface of the liquid, will give readings which are in close agreement with daylight observations. The exact position of the lamp can be readily determined by making observations in daylight and adjusting the lamp to the point at which similar readings are obtained. The polariscope hood makes a convenient place for this observation at night.

Indicators*

By H. A. Cook

Probably the best known theory of indicators is that of Ostwald, which in substance, is, indicators are acids or bases the undissociated molecules of which have a color different from that of their dissociation products. In this theory it was assumed that the anion of an indicator acid, for instance, has a color different from that of the undissociated molecule.

Cohn (1) defines an indicator as follows: "An indicator, in chemistry, is a substance used for the purpose of affording ocular evidence regarding the condition of acidity, alkalinity or neutrality existing in a liquid; . . . "

More in accord with the modern conception of acidity and alkalinity is the following definition as given by Prideaux (2): "In its broadest sense the chemi-

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cal indicator may be defined as a substance which, when added in small quantities, shows the appearance or disappearance of a chemical individual (ion or molecule) by a conspicuous change in color . . . . The study of indicators is chiefly interesting from three points of view; first, there is the question of their sensitivity, i. e., the accuracy with which they can be used for titrations and colorimetric estimations. Second, in the investigation of the H^+ and OH^- equilibria in which they play a part. Third, the relation between color change and constitution."

In this paper it is not proposed to go into the various factors which formulate a theory of indicators. We are concerned chiefly with the first and second points brought but by Prideaux in the above definition of indicators, i. e., their sensitivity and their use in determination of the H^+ and OH^- equilibria.

During the past few years, the conception of acidity and alkalinity has undergone a radical change. There is no necessity here of going into the details of the ionic theory or a discussion of the dissociation of acids or bases. It has been thoroughly demonstrated that there is a dissociation of the H ions and the degree of this dissociation is the important consideration in acidimetry.

In all aqueous solutions there are at all times both dissociated and undissociated ions. These ions in a solution are dissociated to different extents. The modern conception is that there is a constant movement, attraction and repulsion, between these ions which are electrically charged, the hydrogen ions carrying a positive charge and the hydroxyl ions a negative charge. It therefore, is a question of the activity of the hydrogen ions with which we are concerned.

The relation of the terms, hydrogen ion concentration, pH values, total acidity, etc., were well covered in a paper presented at this meeting last year by Mr. King (4). This relationship has been further discussed in the October number of the *Record*, this year, in a paper by H. F. Bomonti and W. R. McAllep entitled, "Characteristics of Clarified Juices at High Temperatures."

Until very recently all reference to reaction values, where any definite values were expressed, have been in terms of total acidity or alkalinity. In the beet sugar industry these terms have had a quite definite meaning and are usually expressed as "gms. CaO per 100 cc." In cane sugar practice there has not been this close an expression of the values. Where definite values were assigned the expression was usually placed in terms of cubic centimeters of some normality of acid or alkali. The more common expression found is "slightly acid to litmus" or "slightly alkaline," often the indicator used was not mentioned. The expression of results at the Experiment Station has been "gms. CaO per 100 cc."

This loose application of the terms acidity and alkalinity has resulted in considerable confusion. It has made it extremely difficult to correlate the results obtained by one factory with those of another or of one man's work with another. The results of much valuable research work has been lost due to inability to interpret the results into values that had definite meaning.

The introduction of the ionic theory with a better understanding of the meaning of the terms hydrogen ion concentration and pH values and the consequent "better definition of degree in 'acidity' or 'alkalinity,' together with improved means of measuring these values, has developed among scientific men in general

an appreciation of how indefinite were those old terms 'slightly acid,' 'distinctly alkaline' and 'neutral.' There is now a clear recognition of the distinct difference between quantity and intensity of acidity and for each aspect there may be given numerical values admitting no misunderstanding." Clark (3).

Aside from the above considerations, it might be well to briefly touch upon some of the recent developments of research work at our Experiment Station which show the desirability of expressing these values in definite terms.

Investigations on clarification carried out by Mr. Bomonti at the Experiment Station demonstrate that the best results in clarification and the largest increase in purity were secured by liming the cold raw juice to a faint color to phenolphthalein. At that time a hydrogen ion apparatus was not available at the Station and it was believed that a reaction existed in the clarified juice which could be expressed in terms of titratible alkalinity to litmus as an indicator. Later, it was found that this relation did not exist. It has since been found that liming to this point corresponds to 8.8 pH.

Investigations on the digestion of juices at high temperatures, by Mr. Bomonti, thoroughly demonstrates that there is a definite reaction, below which juice will not keep, without inversion, over a period of 22 hours. This reaction is directly related to hydrogen ion concentration or pH values and does not have any relation to total acidity or alkalinity.

More recent investigations, by the writer, substantiate Bomonti's findings and will probably establish more definitely the hydrogen ion concentration at which inversion takes place in clarified juices. We also expect to be able to establish the rate of inversion at the different hydrogen ion concentrations and to establish the rate at which clarified juices become acid at different initial reactions and at different temperatures.

It is a definitely established fact that there is a narrow margin of hydrogen ion concentration at which the maximum results in clarification are obtained. We believe that we are now prepared to state that there is a definite hydrogen ion concentration below which inversion may be detected in clarified juices. The inversion of sucrose in clarified juices begins at a much more alkaline reaction than was heretofore realized. The inversion of pure sucrose has, for years, been used as a measure of hydrogen ion concentration, but it had not been established that there was just as definite a relationship existing in clarified juices.

With these facts in view, it is entirely advisable to place the reaction control of our Hawaiian factories on a uniform and intelligible basis.

Cane juice can roughly be described as a complex aqueous solution containing sugar. This solution therefore contains both hydrogen ions and hydroxyl ions. The raw juice contains an excess of hydrogen ions and the clarified juice usually contains an excess of hydroxyl ions.

We are directly faced with two problems in the clarification process; first, the purification of the complex aqueous sugar solution to the extent that the greatest amount of impurities may be eliminated from the juice so that the highest possible recovery of sugar may be obtained; second, to have this clarified juice at such a reaction that the minimum of inversion will result through the process.

There have been many conflicting statements made as to how acid a juice may be allowed to become before there is any danger of loss by inversion. It has been stated by some authorities that there is practically no danger of inversion in running the house "slightly acid." Here is another instance of the looseness with which the term acid is used, for most of these authorities do not state what is meant by the term "acid house," that is, whether they mean acid to litmus, phenolphthalein or true neutrality. Other authorities have definitely stated that the juice can be carried "neutral" or "slightly acid" to litmus without loss from inversion. We have found at the Experiment Station that inversion does take place in juices that are definitely alkaline to litmus and even definitely alkaline to true neutrality.

Placing the chemical control of the sugar factory on a hydrogen ion concentration basis involves means for this determination. There are two generally used methods for this purpose. First, the electrolitic measurement by means of the hydrogen electrode. This method is, for all commercial purposes, the most rapid, convenient and accurate but is not yet adaptable for general use in sugar house laboratories. On this account it will not constitute a part of this paper. Further information can be obtained from numerous sources, notably, "The Determination of Hydrogen Ions," by W. Mansfield Clark, or the determination can be demonstrated at this Station.

The second method for this determination is known as the colorimetric method. This method is based on the use of indicators.

The use of an indicator method for the determination of hydrogen ion concentration involves a choice of indicators. Indicators should be selected in reference to their sensitivity, their freedom from salt and protein error, their definiteness of color change and the proper pH range of the indicator. Several indicators have been tried out at this Station but for our use those proposed by Clark & Lubs (5) have been found to be the most useful.

The distinctive advantages of the indicator method are the ease and the rapidity with which the approximate hydrogen ion concentration of a solution can be measured. The introduction of improved indicators, the charting of their pH ranges, better definition of degree in "acidity," or "alkalinity," make this method a desirable one for our purpose.

Litmus and phenolphthalein have been the almost universally used indicators for sugar house control. Litmus has played an important role in acidimetry and should be given full credit, but its use in other than the cane sugar industry has now almost become obsolete. It is not a reliable indicator for sugar house control. There are several reasons for this statement, among them the following: The color change takes place through a pH range of 4.5 to 8.3, the so-called neutral point to litmus is approximately 6.3 pH. These two facts in themselves are against the use of litmus for our purpose. The pH range is so broad that the color change is very indefinite and the approximate pH value of any hue cannot be definitely determined. The neutral point is so far on the acid side of true neutrality that this point is valueless. True neutrality is pH 7.0. There are two other facts which make the use of litmus objectionable, i. e., the source and degree of purity of the product. Litmus is a complex of many compounds, chief among

which are azolitmin, erythrolitmin, erythrolein and spaniolitmin. Of these, azolitmin is the most important, but, the azolitmin of commerce is of uncertain composition. The composition of the different preparations varies with the source and also with the extent of the action of alkali and air upon the crude material. Products secured on the market are of variable purity and seldom is a pure product obtained. For the determination of pH values, indicators of the highest purity must be used.

Phenolphthalein is of comparatively recent use in Hawaii and is the best indicator yet found for its purpose. It is a one color indicator and has a pH range from 8.3 to 9.8, depending a little on the concentration used. The concentration used in the clarification investigations was 0.1 per cent. At this concentration it first shows color at about 8.3 pH in colorless buffer solutions. In cane juice it does not show color till about 8.6 to 8.8 due to the natural color and turbidity of the juice. This appearance of color is quite definite and regular in different juices.

There are several colorimetric methods in use for the determination of hydrogen ion concentration values; these are all based upon the use of buffer solutions and appropriate indicators. Only what is known as the spot test method will be described in this paper. For further information the reader is referred to the references already cited. The spot test, as far as can be learned, was introduced by L. D. Felton (6). This method was originally adopted for biological or pathological use where only small quantities of liquid were available. The method has since come into quite general use. The comparisons are made with buffer solutions of known value.

The spot test method is now used for the control of some of the sugar refineries on the mainland and is also used by a few of the mills in Porto Rico. H. Z. E. Perkins (7) has described the method in use at the American Sugar Refinery at Chalmette, La. A previous article was published by Brewster and Raines (8) on "Control of Reaction in Sugar-House Liquors." Buffer solutions were used as the basis of these comparisons. Crockett Refinery was probably the first to apply the spot test method without the use of buffer solutions.

The use of buffer solutions carefully standardized by means of the hydrogen electrode is undoubtedly the correct procedure for colorimetric determinations.

Against all colorimetric methods there are distinct drawbacks for their use in plantation laboratories. It must be understood that the colorimetric method, at its best, is an approximation of the true value. With indicators and methods so far developed, results are secured which should check to within 0.2 pH. Adaptions of the method can be used which are of distinct value and without doubt far superior to the present method of expressing reaction values.

One of the main objections to the use of the regular colorimetric method is the use of buffer solutions. Buffer solutions are troublesome to prepare. Very pure chemicals must be used; these must be repurified by several recrystallizations. Several sets of buffer solutions have been made up at the Station following the directions of Clark (3), but have not given the correct values. In nearly all cases the solutions have had to be adjusted considerably before use. This fact may be due to the purity of the chemicals used or to other reasons. M/5 NaOH

is especially difficult to prepare and keep free from CO_2. The prepared buffer solutions should always be checked by means of the hydrogen electrode before use.

Another objection to the use of buffer solutions is the fact that they cannot be counted upon to retain their values for any definite length of time, even though it is, of course, always assumed that precautions are taken to avoid contamination and maintain perfect cleanliness in operations. It is important that the buffer solutions be frequently checked with the hydrogen electrode.

It is desirable, therefore, to develop a method, if possible, by which the advantages of the colorimetric method can be retained and yet avoid the use of troublesome buffer solutions. The only way we have found it possible to do this is to prepare standard color charts which are in agreement with standard buffer solutions with the indicator added.

Crockett Refinery, realizing the need for more definite control of the refinery liquors, developed a modification of the spot test method by preparing a color chart for the comparisons. The range of indicators in this chart is not adaptable to our use, but we are working along the same line and hope to develop a chart for use on our plantations.

Twigg Smith first reproduced the colors with oil paints on canvas. McCleery and Smith used charts prepared from these colors for a part of this past year and secured quite good results. However, we desired to improve these charts and have been endeavoring to reproduce the colors by means of dyes on celluloid. This gives a more satisfactory color than does the oil and canvas. There have been numerous difficulties to overcome in preparing these charts and the work has taken considerably more time than was originally anticipated. However, we fully expect that the results secured from their use will fully repay the time and effort expended.

There are certain conditions which must be conformed to in using this method. In practice, conditions must be comparable to those under which the standards were prepared. Indicators of the highest purity must be used. The same concentration of indicator must be used. The depth of indicator color in the spot plate must be the same, therefore, spot plates must be used which duplicate those from which the standards were prepared. The same amount of indicator and sample must be used as was used in preparing the standards. Cleanliness must be observed.

Equipment Required

Eight oz. glass stoppered bottles for stock solution of indicators; 1 or 2 oz. dropping bottles for use with the indicators. The best type of dropping bottle for this purpose is the regular pathological dropping bottle. A substitute may be prepared from a small, fairly large-mouth bottle, fitted with a cork through which a medicine dropper is inserted. A spot plate with depressions of the following dimensions: 7 mm. depth and 20 mm. in diameter. Steps have been taken to assure a supply of these plates. 1 cc. pipettes.

Method of Determination

Four drops of the appropriate indicator are placed in the depression of the spot plate; to this is added 1 cc. of the sample. A moment should be allowed for the dissemination of the indicator through the sample. Stirring is not advisable.

This color is then compared with the colors of the chart and the pH value of the color on the chart with which it coincides is taken for the pH value of the sample.

It is desirable that the readings be checked by overlapping indicators. For instance, cresol red covers most of the range of phenol red, and thymol blue overlaps a large portion of the higher range of cresol red.

Dilution

Where the color or turbidity of the juice interferes with the color of the indicator, dilution of the juice may be resorted to. In a well buffered solution, especially one around the neutral point, pH 7.0, dilution affects the pH value to a very slight extent. It has been found that there is a small dilution error in cane juices. This error is slight around the neutral point. The error increases the farther the value lies in either direction from the neutral zone amounting to 0.1 to 0.3 pH. Dilution does not affect the pH value as determined colorimetrically to quite the extent it does readings obtained by the electrode. A 1-3 or 1-5 dilution will be sufficient for nearly all cases.

For the purpose of making dilutions it is well to use test tubes calibrated for this purpose. This calibration need not be especially accurate. It is best to have the test tubes marked at 5 cc. and 20 cc. for the 1-3 dilutions and at 5 cc. and 30 cc. for the 1-5 dilutions. The tube can be rinsed out with a portion of the sample, filled to the lower line with the sample and then to the upper line with distilled water.

Some plates have substances on the surface of the plate or in the glazing which cause some degree of ionization. Such a condition will have to be overcome and is usually accomplished by letting a solution of sulfuric-cromic acid stand on the surface of the plate for an hour or so, then washing thoroughly with distilled water. It is well to follow this procedure every few days.

Indicators and Their Concentration for Use

To cover the full range of reactions of the juices found in the sugar house several indicators will be required. The following indicators will usually cover the range through raw juice to the clarified juice; brom cresol purple, brom thymol blue, phenol red, cresol red, thymol blue and phenolphthalein. All of these indicators are not necessary, however, in factory practice. In practice, two or possibly three indicators will serve all purposes. These will probably be: phenolphthalein together with phenol red, cresol red or thymol blue.

The preparation and concentration of the indicators is as given by Clark (3) excepting for phenol red and cresol red. With these two indicators a higher concentration was found advisable. The method of preparation as given below is taken directly from Clark:

"For the preparation of these stock solutions one decigram (0.1) gram of the dry powder is ground in an agate mortar with the following quantities of N/20 NaOH."

Indicator	Color Change	pH Range	cc. N/20 NaOH
Brom cresol purple	Yellow-purple	5.2-6.8	3.7
Brom thymol blue	Yellow-blue	6.0-7.6	3.2
Phenol red	Yellow-red	6.8-8.4	5.7
Cresol red	Yellow-red	7.2-8.8	5.3
Thymol blue	Yellow-blue	8.0-9.6	4.3

Clark advises making these up to 25 cc. with distilled water for stock solutions and diluting in the dropping bottles to a concentration of .04 per cent, 0.02 per cent for phenol red and cresol red. We have found that it is just as well to make immediately up to 250 cc. with distilled water thus making in all cases a .04 per cent solution.

Phenolphthalein should be made up in .1 per cent solution. The salt should be dissolved in alcohol and then diluted with water so that the alcoholic strength is approximately 50 per cent by volume. The acidity of the alcohol should be neutralized by adding N/100 NaOH to a slight pink then adding one drop N/100 sulfuric acid.

McCleery and Smith both experienced some difficulty in the use of brom thymol blue. They obtained results which averaged about .8 pH low. Until we have determined the cause of this, we are not advising the use of this indicator. The range is lower than is usually needed for factory practice so that this indicator is not needed. We have found, too, that we can extend the range of phenol red a little lower and thus overlap with brom cresol purple for the lower range.

For conditions where the P_2O_5 content of the juice is such that the liming can be carried to the point advised in clarification practice, phenolphthalein is the best indicator to use. The cold raw juice should be limed to a slight color to phenolphthalein. This will give a reaction close to 8.8 pH. The clarified juice from this liming should not fall below 8.0 pH. The reaction of the clarified juice should be as carefully controlled as the reaction of the raw limed juice. For this point either cresol red or phenol red can be used.

If for any reason it is not possible or desirable to carry the liming to the extent above stated it is possible to establish a definite reaction and control it by the use of one of the above indicators. If a point is used lower than that which has been found advisable it should be made as high as possible and the control maintained as carefully as at the higher point. As stated before, litmus should not be used for the basis of control, for a definite reaction cannot be established by its use. If it is desired to lime between the litmus value and phenolphthalein, a neutrality reaction of 7.0 can easily be established with phenol red by liming to a faint pink. If 7.5 is desired a faint pink to cresol red will give this point. If 8.0 or 8.2 is wished, it can be secured by liming to a distinct red to cresol red or a faint blue to thymol blue. Where a factory wishes to lime to a faint alkalinity to litmus, or an acid reaction, it can be secured much more definitely by using brom cresol purple and liming to a faint purple. The above considerations can be applied directly in the factory.

The color chart is intended, primarily, for the use of the chemist in the laboratory. It is important that a close control of the mill juices be maintained. By this method a record of the reactions can be kept. The reactions and the terms of expressing them will be a definite language. It will be possible to make direct comparisons of the work of one mill with another and the chemist will be able to check up his practice with that of others and with clarification investigations.

It is not claimed that the adoption of this method will be a cure-all for the troubles in the cane sugar practice. There will undoubtedly be difficulties experienced in using the method and in some cases difficulty in matching colors. As stated before, the use of indicators is only an approximate method. It will, however, be a step far in advance of present practice and will eliminate much of the guesswork in factory control.

There is much to be learned about indicators and their use. New and better indicators will undoubtedly be developed and better methods of control will follow. There is a great need for closer control of the reaction of the juices in the sugar house than has been generally realized. We must take advantage of the best methods available and realize the importance as well as the limitations of their application.

It is admitted that the use of this method will require a little more attention to details, but it is being done in one of the Hawaiian factories and in several elsewhere, so it can be done here. In all processes best results are obtained by attention and effort. This extra attention, once it is established, will not be marked in its requirements but results are bound to be manifested.

References

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A Mathematical Analysis of Boiling Systems*

By Walter E. Smith

In this analysis, the writer has sought to compare a number of boiling systems, using as a basis of comparison the weight of gravity solids in massecuite per unit of gravity solids in syrup.

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It is evident that the system capable of producing its sugar from the smallest quantity of massecuite will be the most economical from the standpoint of fuel; it also seems probable that such a system will produce sugar of the best refining qualities, all other conditions being equal.

The production of good filtering sugar is dependent on securing a minimum concentration of what we have termed non-settling matter in massecuite from which the commercial sugar is produced. For a given concentration of non-settling matter in syrup, the minimum concentration in massecuite must obviously be produced under the conditions which produce the smallest quantity of massecuite, since the increase in quantity of massecuite can only be brought about by boiling back additional quantities of molasses having a much higher non-settling matter concentration than the syrup; this, of course, must result in an increase in the non-settling matter concentration of the massecuite and be reflected in a reduced filtration rate of commercial sugar.

The assumptions used in the calculations that follow approximate results actually attained in normal factory practice. It does not follow, of course, that the results indicated by these calculations will hold good for factories where the operating conditions vary to any extent from the assumptions used, but it is probable that similar relationships will exist between the various boiling systems under other conditions, and the same methods of calculation may be applied. The calculations are based on gravity purities, conversion from apparent to gravity purities being affected by assuming a difference of 0.8 at 86.0 apparent purity, and 1.0 for each 10.0 points thereunder, giving 57.1 gravity for 54.0 apparent purity of low grade massecuite. Molasses is assumed at 36.0 gravity purity; the commercial sugar is taken at an average of 97.0 polarization, with .25 deterioration factor. Massecuite yield has been calculated on a basis of a difference of 20.0 apparent purity, or 18.0 gravity purity, between massecuite and molasses. In considering double purging, it has been thought feasible to raise 70 apparent purity No. 2 sugar to 90 apparent purity when producing a molasses of 54.0; in actual practice, no difficulty has been experienced in raising No. 2 sugar 16-17 points with a molasses of 48-50. By a slightly greater dilution of the magma or the use of a small quantity of wash water at the centrifugals, the double purged sugar could be brought to a purity of 20 points higher than the original low grade sugar without difficulty. When the molasses has been held to 50 apparent purity, the double purged sugar has been assumed only 16.0 points higher than the magma.

Two-Boiling System

In the so-called "two-boiling system," the commercial sugar massecuite consists of a mixture of syrup, remelt, and No. 1 molasses, at such purity that the molasses from this massecuite is suitable for low grades. The factors affecting the quantity of massecuite are purity of syrup and the purity to which the low grades are reduced (assuming that the massecuite will remain 20 points higher than the No. 1 molasses). If the purity of the remelt remains constant, decreasing the purity of the low grades brings about a marked increase in the quantity of massecuite; if, however, we assume the purity of remelt to also vary with the

low grade massecuite purity, that is, to be for example 16.0 higher than the low grade purity, the sum of commercial sugar massecuite and low grade massecuites remains very nearly constant. This system will show to worst advantage where the purity of low grades is low—50 to 52—with the usual drop of 20.0 from massecuite to molasses. Where a sugar of high polarization is produced with this system, it is usually attained by washing in the centrifugals; apart from its effect on the keeping quality of sugar, this is likely to raise the molasses purity, thus further increasing the quantity of massecuite per ton of sugar.

Pioneer System of Boiling

The so-called "Pioneer system" of boiling is based on a principle entirely different from that of the two-boiling system. In the Pioneer system, the first strike is boiled of syrup and remelt, no molasses from previous boilings being taken back; all the molasses from this so-called "A" strike is taken into the following strike, designated as "B." Under certain conditions, the molasses from the "B" strike may be of proper purity for low grades; if not, it is again taken in, the third strike of the series being designated as "C." Normally, the "C" molasses will be suitable for low grade massecuite, and it is not often necessary to boil a fourth, or "D" strike.

The following summary showing No. 1, No. 2 and total massecuite per unit of gravity solids in syrup will serve to show the effect of the various factors and conditions on the gravity solids in massecuite per unit of gravity solids in syrup:

	(Syrup 86.8 Gr. Purity; Sugar 97.0 Pol.; 98.04 Purity)	Massecuite with 54 Pur. Low Grade 1	2	Total	Massecuite with 50 Pur. Low Grade 1	2	Total
	"Two-Boiling System"						
1	70 A. P. Remelt	1.77	.43	2.20	1.99	.37	2.36
	"Pioneer System"						
2	70 A. P. Remelt (A & B only)	1.57	.43	2.20	1.73	.37	2.10
3	79 A. P. Remelt (A, B & C strikes)	1.68	.35	2.03	1.63	.31	1.94
3a	75 A. P. Remelt (A, B & C strikes)	1.74	.37	2.11	....	...	....
3b	75 A. P. Double purged to 90 A. P.	1.58	.37	1.95	....	...	....
3c	79 A. P. Remelt	1.51	.34	1.85	....	...	....
3d	79 A. P. Remelt	1.52	.34	1.86	....	...	....
3e	79 A. P. Remelt	1.54	.34	1.88	....	...	....
3f	70 A. P. Double purged to 90 A. P.	1.48	.43	1.91	....	...	....
	(In systems 3c-3f the B strike is only mixed to desired purity, and not to fixed volume, as explained in later paragraph.)						
4	70 A. P. Remelt double purged to 90 A. P.	1.59	.43	2.02	1.59	.37	1.96
5	D. P. Remelt (90) with 2A and 1B	1.51	.43	1.94	1.50	.37	1.87
6	Same as 5, except no syrup in B	1.55	.43	1.98	1.54	.37	1.91

In systems 2-3b, the mixtures of the various products have been made in such a way as to meet the conditions of actual practice, that is, that each strike shall be of the same volume—a full pan. This is, of course, required by considerations of economy and simplicity of practice, since either A, B or C strikes are based interchangeably on the same foundation of seed and syrup from a central grain-

ing pan. In effect, however, this may cause an increase in the massecuite per unit of solids in syrup as can be readily seen from the fact that with 79 apparent purity remelt, using three strikes to reduce the molasses purity, the quantity of massecuite is actually 0.11 greater than where only two strikes are required as in "2," with 70 apparent purity remelt.

The reason for this lies in the fact that in systems 3 and 3a, the average massecuite purity is actually lower than in 2; it is of interest to note that in the systems tabulated, the quantity of massecuite varies directly with the average purity of massecuite.

In systems 3c-d-e, the usual procedure has not been followed. Instead of producing equal quantities of A, B and C massecuite, the A molasses is mixed with sufficient syrup to make a B strike of such purity that with a 20 point drop, the molasses will be suitable for low grades. In 3c, the A strike takes in neither remelt nor molasses; the B strike is equal to 72 per cent of the A strike, and the A sugar comprises 65 per cent of the total commercial sugar. In 3d, sufficient No. 2 sugar is taken into the A massecuite for seed, and the B massecuite made up as before; in this case, the B massecuite decreases to 71.5 per cent, while the A sugar remains constant at approximately 65 per cent. In 3e, practically all of the remelt is taken into the A strike; the B massecuite drops to 69 per cent, with the A sugar a fraction over 65 per cent.

In system 3f, where 70 apparent purity remelt is double-purged and the B massecuite is boiled at suitable purity to give molasses ready for low grades, the B massecuite is less than 60 per cent of the A massecuite, with the A sugar comprising 70 per cent of the total production. The principle of making the respective volumes of A and B massecuite not necessarily equal offers some saving of massecuite, though it does introduce the complication of building a suitable grain in less than a full pan. An apparently satisfactory compromise is found in system 5, wherein with double-purged remelt, it is found possible to boil only one B strike for two A strikes. Here the A sugar comprises 75 per cent of the total commercial sugar produced, a condition very close to the ideal.

The system capable of producing sugar of highest refining quality would, of course, be a system of straight boiling, wherein all the commercial sugar was crystallized from a massecuite containing no molasses. For example, we could make up the first massecuite from syrup, double-purged remelt, and 96 purity sugar coming from the B massecuite; the molasses from this strike would be boiled to grain, and from this a sugar of 96 purity produced, to be remelted or used partly as seed for the first strike. Calculating on a basis of producing 98.0 polarization sugar, this system would contain 1.81 tons gravity solids per ton of gravity solids in syrup in the A and B massecuites; this figure is only slightly higher (0.04) than the two-boiling system, and has the advantage of producing the best sugar obtainable with any system of boiling. It is, however, 20 per cent higher in solids in massecuite than the method producing two A's and 1 B strike, with double-purged remelt.

Summary

Assuming that filtrability of commercial sugar is dependent on the concentration of non-settling matter in the massecuite from which it is produced, we may

conclude that this concentration may be further affected by boiling methods. The system requiring the least quantity of massecuite per unit of solids in syrup should give the best results, since any addition to the quantity of massecuite can only be made by additional boiling back of molasses, which in turn will increase the non-settling matter concentration of the massecuite. The system producing the least massecuite is that which has the highest average massecuite purity.

From this standpoint, the "two-boiling" system is the most objectionable, since this gives the lowest possible massecuite purity and the highest amount of massecuite per ton solids in syrup.

The first step in the direction of straight-boiling—the ultimate ideal—is the Pioneer system, which produces part of its sugar from strikes of high purity; the last strike of the series is equal to that found in the "two-boiling" system, but the sugar produced in the other strikes clearly represents an improvement. Present practice, however, in seeking to apply the principles in a manner most easily followed, and least subject to confusion, makes A, B and C massecuite of equal quantity; it can be shown by calculation, however, that less massecuite is produced if the massecuites of lower purity are reduced to the minimum. For example, with syrup of 86.0 apparent purity, double-purged low grade sugar of 90 apparent purity, and 54.0 apparent purity low grades, a system can be followed which will produce two A strikes to one B strike—securing 70 per cent of the total commercial sugar from A strikes.

Methods of Calculation

The following scheme of calculation will show the methods used in arriving at the results indicated, and may serve as a guide to be followed in calculating similar data for a different set of factory conditions.

"TWO-BOILING SYSTEM"

Assumptions:

Syrup	86.8	Gravity Purity	
Final Molasses	36.0	" "	
Commercial Sugar	98.04	" "	(97.0 Pol.)
Remelt (No. 2 Sugar)	72.4	" "	
No. 1 Massecuite	76.0	" "	
No. 1 Molasses	57.1	" "	

By formula, the total yield of commercial sugar will be:

$$\frac{98.04\ (86.8 - 36.0)}{86.80\ (98.04 - 36.0)} = 92.486\%.$$

For each 100 tons of gravity solids in syrup, we will then have:

86.8 tons sucrose × .92486 = 80.28 tons sucrose in commercial sugar, with the following distribution of sucrose and solids in syrup:

	Sucrose	Gravity Solids
Commercial Sugar	80.28	81.88
Final Molasses	6.52	18.12
Syrup	86.80	100.00

Turning our attention next to the low grade massecuite, we find that for our assumed conditions the yield of No. 2 sugar at 72.4 gravity purity is:

$$\frac{72.4\ (57.1 - 36.0)}{57.1\ (72.4 - 36.0)} = 73.5\%.$$

That is, 73.5 per cent of the sucrose in low grade massecuite is returned in the No. 2 sugar, while (100 — 73.5 = 26.5%) is eliminated with the molasses. In other words, the sucrose in final molasses is equal to 26.5 per cent of the weight of sucrose in No. 2 massecuite; since the sucrose in final molasses is 6.52 tons per 100 tons of gravity solids in syrup, the quantity of sucrose in No. 2 massecuite is:

$$\frac{6.52}{.265} = 24.60 \text{ tons sucrose.}$$

$$\frac{24.60 \text{ tons sucrose}}{.571 \text{ (Gravity Purity)}} = 43.08 \text{ tons gravity solids.}$$

The No. 2 massecuite is therefore distributed as follows:

	Sucrose	Gravity Solids
No. 2 Massecuite	24.60	43.08
Final Molasses	6.52	18.12
No. 2 Sugar (Remelt)	18.08	24.96

The base of the No. 1 massecuite then becomes:

	Sucrose	Gravity Solids
Syrup	86.8	100.00
No. 2 Sugar	18.08	24.96
Base (83.93 Gravity Purity)	104.88	124.96

We must now add sufficient No. 1 molasses of 57.1 gravity purity to reduce this base to 76.0 gravity purity; the quantity required is arrived at by formula:

$$\frac{83.93\ (76.00 - 57.10)}{76.00\ (83.93 - 57.10)} = 77.794\%.$$

This means, then, that 77.794 per cent of the sucrose in the finished massecuite at 76.0 gravity purity is contained in the base of the No. 1 massecuite. Then, 104.88 ÷ 0.77794 gives 134.82 tons, the quantity of sucrose in the finished massecuite; at 76.0 gravity purity, this is equal to 177.39 tons of gravity solids.

The composition of the No. 1 massecuite is then as follows:

	Sucrose	Gravity Solids
Syrup	86.80	100.00
No. 2 Sugar	18.08	24.96
No. 1 Molasses	29.94	52.43
No. 1 Massecuite	134.82	177.39

The yield of the No. 1 massecuite is:

$$\frac{98.04\ (76.0 - 57.1)}{76.00\ (98.04 - 57.1)} = 59.553\%.$$

The No. 1 massecuite is therefore distributed as follows:

	Sucrose	Gravity Solids
Commercial Sugar	80.28	81.88
No. 1 Molasses	54.54	95.51
No. 1 Massecuite	134.82	177.39

The quantity of No. 1 molasses used in the No. 1 massecuite must be deducted from the total No. 1 molasses produced, since this quantity may be considered as having been "borrowed" from process; in actual practice, this amount is in circulation in the No. 1 massecuite.

	Sucrose	Gravity Solids
Total No. 1 molasses produced	54.54	95.51
Used in No. 1 massecuite	29.94	52.43
No. 1 Molasses to Low Grades	24.60	43.08

This quantity agrees with our previous calculation. The total sucrose introduced in syrup is accounted for in commercial sugar and final molasses, thus balancing the system.

SUMMARY

		Per Unit Gravity Solids in Syrup
No. 1 Massecuite	177.39	1.77
No. 2 Massecuite	43.08	.43
Total	220.47	2.20

PIONEER SYSTEM

Assumptions:

Syrup	86.8	Gravity Purity
Final Molasses	36.0	" "
Commercial Sugar	98.04	Purity (97.0 Pol.)
"A" Sugar	98.69	" (98.0 Pol.)
Remelt (No. 2 sugar)	72.4	Gravity Purity
Low Grade Massecuite	57.1	" "

The quantity of low grade massecuite and remelt will remain the same as in the previous system, since the factors affected by these quantities have not been changed.

In this system, we assume the use of a small amount of seed in the A massecuite, which is therefore made up as follows:

	Sucrose	Gravity Solids
Syrup	86.80	100.00
No. 2 Sugar	4.03	5.56
(86.05 Gravity Purity)	90.83	105.56

The yield of this massecuite is:

$$\frac{98.69\ (86.05 - 68.05)}{86.05\ (98.69 - 68.05)} = 67.376\%$$

	Sucrose	Gravity Solids
"A" Sugar	61.20	62.01
"A" Molasses	29.63	43.55
Total A Massecuite	90.83	105.56

The total No. 2 sugar produced as a result of the use of 100 tons gravity solids in syrup in "A" massecuite would be:

	Sucrose	Gravity Solids
No. 2 Sugar due Syrup in "A"	18.08	24.96
Actually used in "A"	4.03	5.56
Excess No. 2 sugar to be used in "B"	14.05	19.40

The production of No. 2 sugar under the assumed conditions is 24.96 tons solids per 100 tons gravity solids in syrup; in order that the system will balance, this quantity must therefore be used, or this proportion maintained between syrup and No. 2 sugar.

The "B" massecuite is made up, then, of the "A" molasses, the excess remelt not utilized in "A," and sufficient syrup and remelt to bring the quantity of "B" massecuite to approximately the same figure as that for "A." This gives us then, the following composition of "B" massecuite:

	Sucrose	Gravity Solids
"A" Molasses	29.63	43.55
Excess remelt due syrup in "A"	14.05	19.40
Syrup	29.87	34.41
Remelt due this syrup	6.22	8.59
"B" Massecuite (75.29 G. P.)	79.77	105.95

Before calculating the yield of this massecuite, we must determine the purity of the "B" sugar, as follows:

From the syrup used in the two massecuites, the total yield will be:

	Sucrose	Gravity Solids
Total	107.90	110.06
"A" Sugar produced	61.20	62.01
"B" Sugar by Difference (97.20 Purity)	46.70	48.05

The yield of the "B" massecuite will therefore be:

$$\frac{97.20\ (75.29 - 57.10)}{75.29\ (97.20 - 57.10)} = 58.562\%.$$

	Sucrose	Gravity Solids
"B" Sugar	46.70	48.05
"B" Molasses	33.07	57.90
"B" Massecuite	79.77	105.95

SUMMARY

(134.41 Tons G. S. in Syrup)		Per Unit Gravity Solids in Syrup
"A" Massecuite	105.56 Tons	....
"B" Massecuite	105.95 Tons	....
Total No. 1 Massecuite	211.51 Tons	1.56
No. 2 Massecuite	57.90 Tons	.43
Total		1.99

STRAIGHT BOILING

Assumptions:

Syrup	86.8	Gravity Purity
Sugar	98.0	Polarization (98.69 Purity)
No. 2 Massecuite	57.1	Gravity Purity
Final Molasses	36.0	" "
Low Grade Sugar:		
Original	72.4	" "
Double Purged	90.4	" "

(In this system, the drop between massecuite and molasses is taken at only 18.4 apparent purity, or 16.6 gravity purity.)

The total yield in this system is found to be 79.97 tons sucrose, and 81.03 tons gravity solids per 100 tons gravity solids in syrup. By the methods illustrated in the previous series, we find that the low grade sugar will yield 57.57 per cent of its sucrose in the form of 90.4 gravity purity double-purged sugar. This gives the following distribution:

	Sucrose	Gravity Solids
Original Low Grade Massecuite	25.77	45.13
Final Molasses	6.83	18.97
No. 2 Sugar (Original)	18.94	26.16
Double-purged No. 2 Sugar	10.87	12.02
Molasses from double-purging	8.07	14.14

In this system, the "A" massecuite is composed of syrup, double-purged remelt, and "B" sugar from the "B" massecuite. The proportions are computed as follows:

	Sucrose	Gravity Solids
Syrup	86.80	100.00
Double-purged Sugar	10.87	12.02
Base of "A" Massecuite	97.67	112.02

The amount of "B" sugar to be added is determined by trial, based on the following known data: All the commercial sugar (79.97 tons sucrose, and 81.03 tons gravity solids) must be crystallized from the "A" massecuite, and the difference between molasses and massecuite purity is assumed at 16.6 points gravity purity. We then simply add trial amounts of 96.0 purity sugar to the base of the No. 1 massecuite, deduct the sucrose and gravity solids for the commercial sugar, and determine the purities of the massecuite and molasses respectively. After two or three trials, the exact quantity of "B" sugar required is readily determined.

	Sucrose	Gravity Solids
Syrup	86.80	100.00
Double-purged Sugar	10.87	12.02
"B" sugar; (96.0 Purity)	18.24	19.00
"A" Massecuite; (88.48 Purity)	115.91	131.02

The yield of this massecuite is known, so it need not be calculated further. The distribution becomes:

	Sucrose	Gravity Solids
"A" Sugar (98.0 Polarization)	79.97	81.03
"A" Molasses (71.89 Gravity Purity)	35.94	49.99
"A" Massecuite	115.91	131.02

The "A" molasses becomes the "B" massecuite, with the yield:

$$\frac{96.0 \quad (71.89 - 57.10)}{71.89 \quad (96.00 - 57.10)} = 50.77\%.$$

The distribution of the "B" massecuite then becomes:

	Sucrose	Gravity Solids
"B" Sugar	18.24	19.00
"B" Molasses	17.70	30.99
"B" Massecuite	35.94	49.99

The low grade massecuite is made up as follows:

	Sucrose	Gravity Solids
"B" Molasses	17.70	30.99
Molasses from Double-purging	8.07	14.14
Low Grade Massecuite	25.77	45.13

SUMMARY

			Per Unit Gravity Solids in Syrup
"A" Massecuite	131.02	Tons	1.31
"B" Massecuite	49.99	"	....
Total No. 1 Massecuite	181.01	"	1.81
No. 2 Massecuite	45.13	"	.45
	226.14	"	2.26

Deterioration of Cane Mill Juices from the Aspect of Acidity Increase*

By W. L. McCleery

For a number of years it has been increasingly evident that during milling operations there is a considerable loss of sucrose from deterioration due to bacterial action. The absence of a direct method of accurately determining sucrose in cane entering the factory has tended to obscure such losses.

Deterioration had been indicated from the comparison of purity differences between first expressed juice and mixed juice in factories operating under the usual conditions, and the lessened difference in these purities when steps were taken to keep the plants in as sanitary a condition as possible. Mr. Elliott, of Paauhau Sugar Plantation Company, and others have done valuable work along these lines. Other tests had indicated that the time consumed in the routine milling cycle was not of itself sufficient to cause appreciable loss through deterioration.

On my inspection visit to the Hawaiian Sugar Company, this year, Mr. Roberts informed me of tests made in 1923 and being continued this year, pertaining to the acidity of the different mill juices. The development of bacteria around the mills results in acid products. In these tests the increase in acidity is used as an index of the amount of bacterial development. In 1923, he had found that the acidity of mill juices in the latter part of the train was as high or even higher than in the crusher juice. This was an unexpected condition as, due to the effect of compound maceration, it would be expected that the acidity would decrease in proportion to the density. Steps were taken to keep down all sour accumulations, etc., as explained later and the results were immediate. On my suggestion the results were expressed as acidity per cent brix. This year, after taking various steps to reduce bacterial action to a minimum, the actual percentage increase of acidity on this basis was found to be very small.

Mr. Roberts has submitted the following report on his work:

During the 1923 crop, several tests were conducted on the milling plant of the Hawaiian Sugar Company to find the cause of the high acidity in the mixed juice. Cane stalks were examined and the juice as expressed by the laboratory mill was so much lower in acidity than that of the mixed juice, that it was evident that the acidity must be increasing in the milling plant.

By analyzing composite samples taken from each mill, from the pans below the mills, from pumps, macerators, juice troughs, tanks and supply pipes, and computing the results, it was evident that the increases in acidity and the subsequent losses due to this action were much larger than had been the prevailing opinion.

The surprising feature, however, was the fact that the increase in acidity from first to last mill was especially marked towards the end of the week, establishing as a practical certainty that the deterioration was mainly due to an increasing unsanitary condition as the week advanced, as the only thorough cleaning was given the mills on Sunday mornings.

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* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

Another feature was the rather large difference of acidity between intake and outflow of the maceration juices, indicating that deterioration was taking place. This was also true in the maceration distributors. (See Table 2.) As soon as these spaces were frequently washed no appreciable increase of acidity was found.

It was expected that the relation of acidity in first mill and mixed juice would be in direct proportion to the dilution applied, but the acidity per 100 cc. was in many cases as high or even higher in the third and fourth mill juices than in the crusher juice.

After data in Table 1 were obtained, a system was started of cleaning and flushing with hot water and lime all spaces through which the juice passed, sometimes three and four times a day, with the immediate result that the percentage of acidity decreased and the clarification improved.

With the beginning of the 1924 crop a routine was started by running hourly, acidity tests on each mill juice and the mixed juice. Acidity figures were inserted in the daily mill reports and each time the increase of acidity was higher than usual; the engineers would take measures to improve the existing conditions. Mr. McCleery on his inspection visit this year advised confining the comparative tests to the mills only, and substituting the figures of *acidity per cent brix,* in place of *acidity per cent dilution.* This was done and all previous work brought to the same standard.

The relatively small increase of acidity in 1924 (Table 3) between Mondays and Saturdays, also between the crusher and last mill, when compared with the data in Table 1 for May, 1923, shows that it is possible for a factory to operate with a comparatively small percentage increase, thereby resulting in considerable saving of undetermined loss around the milling plant.

TABLE I

AVERAGES FOR MAY, 1923

	1st Mill			2nd Mill			3rd Mill			4th Mill		
	Brix	Ac. p. 100 cc.	Ac. p. 100 Bx.	Brix	Ac. p. 100 cc.	Ac. p. 100 Bx.	Brix	Ac. p. 100 cc.	Ac. p. 100 Bx.	Brix	Ac. p. 100 cc.	Ac. p. 100 Bx.
Mondays	19.70	.017	.086	9.10	.014	.154	6.24	.010	.160	2.88	.006	.209
Tuesdays	20.31	.018	.089	9.66	.015	.155	6.00	.013	.217	2.77	.010	.361
Wednesdays	20.24	.016	.079	9.50	.017	.179	5.80	.016	.276	2.52	.015	.595
Thursdays	19.60	.015	.077	8.70	.014	.161	5.40	.015	.278	2.20	.016	.727
Fridays	21.00	.017	.076	8.55	.016	.187	5.20	.016	.308	2.05	.015	.732
Saturdays	20.40	.019	.079	8.90	.020	.225	5.10	.020	.392	2.05	.021	1.024
Average	20.21	.017	.084	9.07	.016	.177	5.62	.015	.267	2.61	.0138	.529

TABLE II

MACERATING JUICE FROM SECOND TO FIRST MILL

Average of 30 Tests	Intake			Outflow		
First day	8.37	.018	.215	8.34	.022	.264
Second day	9.05	.021	.233	8.92	.027	.303
Third day	9.02	.023	.230	9.07	.033	.364

TABLE III

AVERAGES CROP 1924

	Average Crop 1924			All Mondays Crop 1924			All Saturdays Crop 1924		
Crusher	19.99	.0096	.048	20.61	.0085	.041	19.70	.0114	.058
First Mill	18.10	.0092	.051	18.57	.0076	.041	18.02	.0112	.062
Second Mill	8.60	.0051	.059	9.00	.0039	.043	8.34	.0061	.073
Third Mill	5.84	.0036	.061	6.10	.0028	.046	5.21	.0040	.076
Fourth Mill	2.13	.0014	.068	2.47	.0012	.049	2.97	.0024	.082

As a result of the work done by Mr. Roberts the writer has made similar acidity tests on his visits to twelve other factories operating under usual conditions. The increase of acidity was found very marked especially in factories with the longer trains. The increase as expressed in percentage, from first expressed juice to third mill juice, and from first to fourth, etc., in factories with longer trains, has been tabulated as given in Table 4:

TABLE IV

ACIDITY INCREASE BETWEEN UNITS EXPRESSED AS PERCENTAGE

Percentage Increase Between Units	1st to 3rd	1st to 4th	1st to 5th	1st to 6th	1st to 7th
Halawa Plantation, Ltd.	62	...	...	...	...
Niulii Mill & Plantation	59	...	...	...	...
Union Mill Company	41	...	...	...	...
Olowalu Company*	...	4	...	...	...
Olowalu Company*	...	24	...	...	...
Olowalu Company*	...	29	...	...	...
Olowalu Company	59	86	...	...	...
Olowalu Company	106	140	...	...	...
Olowalu Company	108	122	...	...	...
Olowalu Company	63	91	...	...	...
Olowalu Company	76	87	...	...	...
Kohala Sugar Company	35	122	...	...	...
Kohala Sugar Company	29	85	...	...	...
Waianae Company	94	100	...	...	...
Hawi Mill & Plantation Co., Ltd.	34	75	88	...	...
Lihue Plantation Co., Ltd.	67	256	300	...	...
Oahu Sugar Co., Ltd., "B"	121	296	435	...	...
Oahu Sugar Co., Ltd., "A"†	77	160	195	...	...
Waialua Agricultural Co., Ltd.	56	109	145	...	...
Pioneer Mill Co., Ltd.	117	141	237	260	...
Pioneer Mill Co., Ltd.	73	105	160	190	...
Ewa Plantation Company	158	285	430	454	525
Hawaiian Sugar Co., May, 1923	218	530	...	...	...
Hawaiian Sugar Co., Crop 1924	19	45	...	...	...

* Tests taken about 20 minutes after starting from a clean mill.

† Test on "A" tandem with unstrained juice pump.

The first three tests for Olowalu Company were taken about twenty minutes after the mill started on three successive mornings. The milling plant at this factory always receives a very thorough cleaning each night. The other Olowalu Company tests were made from 1½ to 2 hours and longer, after the first tests were taken. The increase was fairly constant after 2 hours. The second test at Oahu was on the "A" tandem which has no mill juice strainer, but uses the new Honolulu Iron Works unstrained juice pump. This tandem also has steeper sides to the juice pans under the mills, than has the "B" tandem. The "A" train has the usual type of strainer with drag conveyor and cush-cush elevator.

The type of mill juice strainer in general use is not self-cleaning and sour accumulations gather under the screens. The juice strainers probably account for the largest part of the acidity increase found in the different factories, the balance coming from sour accumulations around the mill beds, cheeks, juice flumes and receiving tanks.

With intensive milling it is probable that acidity increase cannot be entirely eliminated, but the evidence above indicates that when precautions are taken to keep the plants in a sanitary condition the increase can be kept down to a small amount.

Antiseptics are hardly to be recommended, as large quantities would have to be used to become effective. The use of a high pressure hot water hose with a small outlet is, in the writer's opinion, the best means of dislodging all accumulations. The flushing should be done every three hours. If done often, only small amounts of water will be needed and a minimum of juice dilution will result. A steam hose, while effective at points close to the nozzle, would not have enough force to dislodge accumulations under the screen in the juice strainer.

The acidity test is simple and can be readily made in any laboratory with N/2.8 sodium hydroxide and sensitive neutral litmus paper. One hundred cubic centimeters of the juice are transferred to a porcelain dish and the standard alkali run in from a burette, a few tenths of a cc. at a time. After each addition of alkali, stir and test with special neutral litmus paper by making a mark across the width of the paper with the stirring rod. The first trace of blue color denotes the end point. Each cubic centimeter of alkali of the above strength represents .01 per cent acidity in terms of minus CaO. Therefore, a crusher juice titrated as above taking 2.1 cc. of alkali will have an acidity of .021 per cent. With a crusher juice brix of 22.1 the acidity per 100 brix or acidity per cent density would be .095, this being obtained by dividing the per cent acidity by the brix and multiplying by 100. See 1924 Methods of Chemical Control, page 42, "Titration with Litmus."

The saving effected by stopping deterioration around the milling plants is hard to express in definite terms, as the decomposition processes are very complex. If it is assumed that the acidity increase is acetic acid at the direct expense of sucrose, the difference between the 1923 and 1924 conditions at Hawaiian Sugar Company amounts to a saving in sucrose of about 1.75 per cent. Because of lack of sufficient reaction data, this figure may not be very close. From the juice purity aspect more definite figures can be given. A depression in mixed juice purity of 1.0 through deterioration, which is not unreasonable according to

other tests, corresponds to about 1.2 per cent sucrose loss. This in turn amounts to approximately an additional 1.0 per cent lessened recovery in the boiling house, or a total of 2.2 per cent. It is therefore evident that any saving of undetermined loss around the milling plants by preventing deterioration is well worth the effort expended.

Petree Process at Puunene*

By Wm. Lougher

It is rather difficult to write anything on the process without a great deal of repetition, after the able manner in which this subject was reported on at the 1923 meeting of this Association.

The results obtained from the two years' operation of the Petree Process are, we believe, a fairly accurate measure of what can be expected from the process at this mill. Following are figures for the crops of 1922, 1923 and 1924, which are calculated on true sucrose base, and are given to show the comparison with the crop of 1922:

Losses: Per cent sucrose in cane	1922	1923	1924
Bagasse	1.8087	2.9808	3.0510
Filtration	1.3076	0.0868	0.2964
Molasses	7.6425	5.8412	6.2769
Undetermined	0.6747	0.3211	0.2387
Total	11.4335	9.2299	9.8630
Recovery	88.5665	90.7701	90.1370

	1922	1923	1924
Cane polarization	14.78	14.25	14.54
Cane fiber	12.53	11.95	12.00
Cane tons per hour	55.78	52.51	61.25
Dilution per cent normal juice	36.09	38.11	34.06
Extraction	98.19	97.02	96.95
Java ratio	82.35	81.85	81.18

The Petree Process has brought about differences in control that do not make the figures of 1923 and 1924 strictly comparable with those of 1922.

The slightly lower Java ratio since the new control, has brought some criticism, and there may be some basis for this, in that the insoluble portion of the mud passing to the fireroom, doubtless goes out at the same polarization as the bagasse, and this should be added to the bagasse losses. However, as there was a 150-mesh screen used on the Peck strainers during this crop, this amount is small and the correction would not effect the Java ratio to a point warranting

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comment. It has also been intimated that losses during clarification, or at the mills may be taking place, which would not show with the present method of control. An examination of the following figures, showing the difference between the purities of crusher juice and syrup, points out that no abnormal losses can be occurring at either stage. These are given for the past five years:

Crop	Purity Difference Between Crusher Juice and Syrup
1920	2.01
1921	3.09
1922	2.23
1923	1.63
1924	1.64

The last two years indicate a much better elimination at the clarifiers than at any time previous. This was further shown by the brilliant juice obtained, and a very decided improvement in the quality and handling of the products throughout the boiling house. Turbidity tests are made several times a day on clarified juice, being measured with a Kopke turbidimeter on a portion of the cooled three-hourly composite sample taken for clarified juice analysis. The object is to obtain an average sample of the juices, besides making all tests at a corresponding degree of temperature; the readings were much lower on the cooled, as against those made on hot juices. We have commonly failed to obtain a reading taken on the hot juice at the clarifiers due to insufficient range on the turbidimeter. The clarity of the juice as measured, with a few exceptions, followed fairly closely the P_2O_5 content of the crusher juice.

The process the past year has been subject to the same objections as were found during the first season's operation, i. e., a tendency toward polished mill rollers, and an excessive amount of juice returning to the mills with the mud. Both are detrimental to the extraction, and together with a grinding rate of 16 per cent faster than in 1923, made us unable to obtain the extraction during 1924 that we anticipated when we commenced our campaign.

The effect of the mud at the mills was not felt as keenly this year as it was during 1923. This was borne out by the steady and increased grinding rate maintained throughout the season, although there was practically no difference in the amount of juice returned with the mud to the mills. It again points out the effect obtained from the use of the 150-mesh screen on the Peck strainers, in having removed a still greater quantity of the very fine cush-cush that formerly was passing through the 100-mesh screen in use last year, all of which is returned at the mills, and passes on to the fireroom, thus further relieving the clarifiers of this quantity, and avoiding the chance of dissolving impurities contained by heat and lime. It may be of interest to note the amount of suspended solids removed by 110- and 150-mesh screens from the primary raw juice.

	Per cent on Weight of Juice	
	100-Mesh Screen	150-Mesh Screen
Before strainer	0.479	0.467
After strainer	0.206	0.143
Per cent removed by strainer	56.99	69.8
Difference removed by 150-mesh screen	......	12.81

I regret that we failed to obtain figures with the 100-mesh screen during 1923. It would be safe to estimate a difference here of 15 to 17 per cent.

The surplus bagasse accumulated this year was approximately 1,600 tons; 1,200 tons of this had to be stored outside of the mill building, the remaining 400 tons were held in the fireroom. The transferring from fireroom to storage pile, and again returning it at the end of grinding, to be used for boiling off, was done with two 18-inch Sturtevant blowers, operated by two 50 h. p. motors, one 1,800 and the other 1,200 r. p. m. in series, using an 18-inch galvanized pipe, over a distance approximately 600 feet from the fireroom to storage enclosure. In addition to this, 614,262 k. w. were supplied for outside power, netting a very substantial credit. During almost the entire crop, bagasse was recklessly consumed at the furnaces to relieve the congestion. The higher rate of grinding doubtless was responsible for a great deal of this accumulation, yet it may be safely stated that the process is responsible for a saving of fifty per cent or more, due to the enormous conservation of heat in juices, cleaner heating surface in boiling apparatus, ease in working of product through the house, gain in higher recovery of sucrose in juice, reduction in labor and materials, most of which means saving of fuel. The cost of manufacture is certainly a very important item in judging the process. This dropped 95 cents per ton of sugar in 1923 and $1.26 in 1924, indicating a saving on our last crop of 63,258 tons, of $79,705. The greater speed of production this year has influenced this figure, but much of the difference is due to saving in labor and material in boiling house, which is directly due to the different method of operation.

The juices are limed after passing through the Peck strainers, the required quantity being controlled at the clarifiers. Primary juice entering the clarifiers is held to a distinct alkalinity to phenolphthalein, while the secondary juice is kept between litmus and phenolphthalein neutrality, giving a combined clarified juice which is alkaline to litmus but slightly acid or neutral to phenolphthalein, this point being found to give best results.

Liquidation of clarifiers has been found most conveniently handled by cutting out one of the units at some convenient time during each week, thus making a cycle of the four units once a month, and is frequently accomplished during a short shutdown for mill repairs, insufficient cane to supply both tandems, or no cane periods. We have found little or no deterioration in the juices occurring during an 18-hour shutdown at the end of each week, and as a guard against any possibility of a change, the temperature is lowered at the heaters and 25 gallons of a 10 Baumé soda solution per clarifier is added continuously over a one hour period before closing down.

Six 30″x18″ Kopke centrifugal separators were installed during this year, and operated the latter two months of the milling season, with the view of eliminating the excessive amount of juice contained in the settlings returned to the mills. The machines are belt driven at 1,225 r. p. m. from 15 h. p. 1,750 r. p. m. motors, and are operated by a crew of three men per shift.

The settlings were limed before passing to the machines, and fed continuously through a nozzle which we designed, to feed at a rate of 15 gallons per minute per machine The feed can be increased or decreased as seen fit, by raising or lowering the pressure head which is regulated by a cone valve to

which is attached a float in the supply tank, having a series of holes drilled in float rod which passes through a pipe guide; adjustments can be made at any time at the top of the supply tank. The separation was effectively done and gave a very clear run-off. The average time per cycle, separating and discharging mud from machines, was approximately ten minutes. The run-off was returned to the secondary cold juice, it being of the same purity as the secondary clarified juice. Besides, the excess lime it contained was corrected, and only a small additional quantity of lime was needed to bring this portion of the juices to the alkalinity required. The mud, being discharged into a mixer, was sufficiently thinned with a small quantity of water that is used in discharging the machines, and its disposal, whether it be returned to the mills or discharged to the sewer, must of course be determined by the per cent polarization it contains. For the period we operated, the average polarization was 5.36 and a moisture of 74.94.

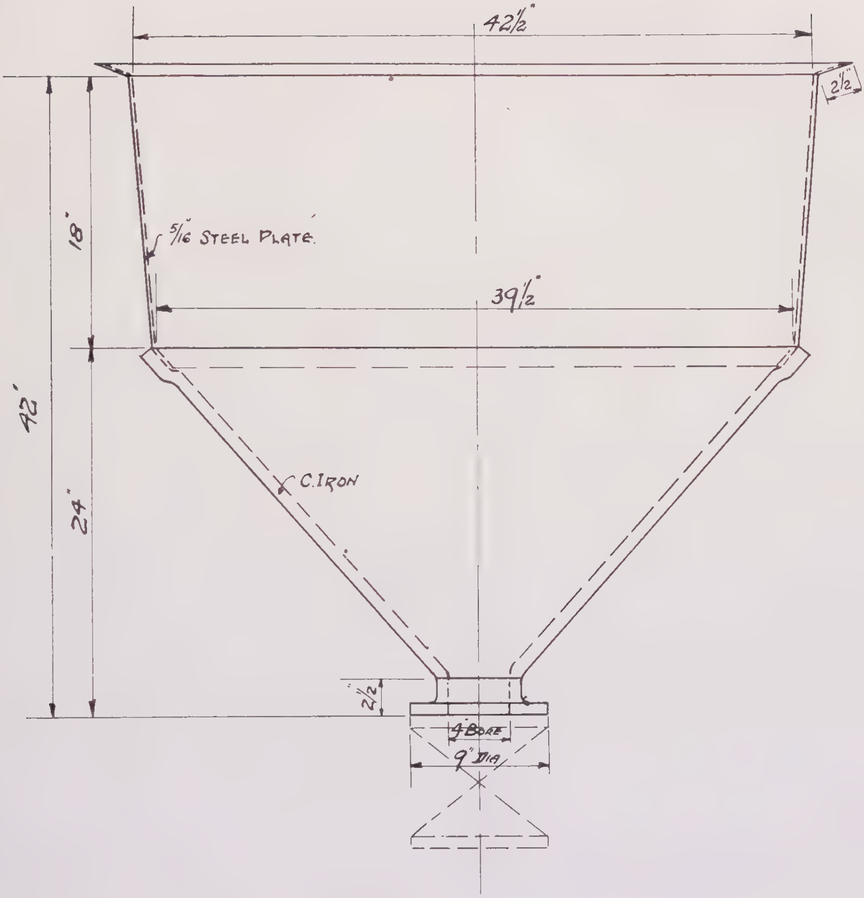
The present installation proved to be only about 60 to 70 per cent of the capacity required to treat the total settlings, which made it impossible to get figures which would be at all comparable. This also prevented us from obtaining the dilution of secondary juice that we had anticipated. Furthermore, had we been able to put the total settlings through the centrifugals it can be safely stated that the polarization of the mud cake would have been reduced by 50 per cent.

The capacity of this station for our 1925 campaign is to be increased by four additional 40-inch machines, which will enable us to treat the total settlings, thereby permitting the necessary dilution at the mills, and the consequent lowering of the brix of the secondary juices, all of which will aid in increasing our recovery.

Best results with the process can only be obtained by keeping the brix of the secondary juice at as low and uniform a point as possible, with a correspondingly lower polarization of the mud. This can be accomplished only by strict observance in maintaining an absolute separation of the juices and the macerating quantities regularly applied at their respective points at the mills; and also by controlling the adjustments on Dorrco pumps on each clarifier to give an even flow of mud at all times corresponding to the quantity and quality of cane ground.

In the event of obtaining a low polarization in the mud, it may be considered preferable to dispose of it to the sewer, discontinuing the practice of its application to the bagasse at the mills. Such a change would not be advisable unless the mill water containing the discarded mud could be distributed over new areas, preventing over-application on that section of the plantation that has been customarily receiving the mill water for irrigation heretofore. However, this point will be decided here when the results from separation of the total settlings are obtained.

The loss of metal or wear of mill rollers with the process is very much less; it appears to be due to the absence of the natural acidity of the juices in the bagasse, which is partially corrected by the lime contained in the settlings. This year we found it necessary to take a light cut with the grooving tool once a month off of all the top rollers, which is somewhat oftener than was our usual practice, but did not require any more than sufficient to remove the polished



Mud cone for Dorr clarifiers.

surface; and it is doubtful even with the somewhat more frequent grooving that we reduced the sizes of the rollers any faster than was done by the action of the acid juices under the former method. However, this, of course, will change in either case, depending on the iron of which they are made and the tonnage ground.

Changes are being made in view of obtaining a better compression of the settlings for the coming season. This consists in lowering Dorrco pumps thirteen and one-half inches, bringing overflow lip of pump to within one and one-half inches above level of juice in the clarifier and in enlarging mud cone at bottom of clarifiers from 18 inches diameter by 6 inches deep to 42½ inches diameter by 42 inches deep. My belief is that this change will aid in further concentrating the settlings and will act as a depositing chamber for the mud as it is scraped off the bottom tray surface. In addition to this, six scraper arms in place of four as originally designed will be used on the lower trays only, which will advance the precipitated bodies to the central cone a little faster than obtained originally.

It was our intention to install the cones last year, but were unable to do so on account of time. The knowledge and description of this arrangement was conveyed to the representatives of the Petree and Dorr Company, at that time and I now understand that this arrangement is being incorporated in their later designs. I was informed by Mr. J. P. Foster recently that the new unit now being installed at the Maui Agricultural Company, Ltd., is equipped with a cone 30 inches in diameter by 20 inches deep. Mr. Foster is presenting his report on the process personally, which will contain an interesting description of piping arrangement for drawing off the mud, replacing the Dorrco pumps. Mr. C. G. Murray, of the Hamakua Mill Company, has expressed his regrets at not being able to contribute, necessary data not being available due to not being through with their harvesting. He no doubt will verbally express his views at the meeting.

My conclusions are that the process as a whole, although it possesses some objectionable features, which can be overcome through experiment and improvement, has given us at Puunene a very substantial return on the money expended, and this is what must finally decide its value to the industry.

Fine Straining of Raw Juice*

By D. G. Conklin

Mechanical difficulties in the fine straining of raw juice have been overcome so that this report will be mainly devoted to the theoretical reasons for fine straining and the subsequent effect of such straining on boiling house work.

The literature of the sugar industry contains numerous references to the desirability of removing suspended matter as far as possible before the operation of defecation. The finely divided matter which is organic is affected by the action of heat and lime, this varying with the state of subdivision of the particles, the extent of liming, and the length of time of exposure to high temperatures. The total amount of impurities liable to go into solution is not great, but its presence is felt throughout the process of manufacture. There is usually an effect found as regards the increase in purity from mixed juice to clarified juice. The H. S. P. A. Experiment Station reports as follows:

> It can then be stated that if cush-cush is present when juice is limed and heated, a part of it goes into solution, adding to the impurities in the juice, with the result that the increase in purity secured during clarification is less than it would have been had no cush-cush been present. From a chemical point of view, keeping the mixed juice as free from cush-cush as possible is desirable; indeed, a more thorough screening of the juice than is the usual practice would probably be profitable. Some efforts have been made along this line and the problem does not seem insoluble. In this connection we would note that the fuel value of the recovered cush-cush is a considerable item. Heavy liming of the settlings, from the same point of view, is an objectionable practice, for the greater

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part of the cush-cush is concentrated in these settlings and conditions are favorable for dissolving further portions of it. While it is true that according to the indications of our experiments, the depression of the purity due to the average amount of cush-cush found in the juice does not appear to be large, a constant effect of this kind results in a loss of considerable magnitude. Record, Vol. XXV, p. 124.

The Station found that the effect of cush-cush elimination was to increase the purity during clarification by 0.2 per cent, and it was found in actual practice that a clarified juice of greater clarity resulted. It was noted that the volume of settlings from strained juice was lessened and that the precipitated impurities settled out more rapidly, particularly in the case of dirty cane. This made for a better capacity at the settling station. It may be possible that the advantage as regards clarification was not due so much to the removal of cush-cush and its soluble components as to the possibility of using more lime for clarification, utilizing the additional settling capacity derived from the removal of much of the suspended matter.

In addition to the advantage of an increase in purity during clarification, there should be an important effect on the quality and quantity of low grade products. This cannot as yet be positively stated, due to obvious difficulty in applying abstruse effects to concrete results. However, the elimination of finely suspended matter is most certainly not deleterious to the working or exhausting of low grade products.

If it is found possible to reduce the cake from strained juice to the same polarization as obtained previously, the loss at this station will be materially reduced. Reports from factories using the fine strainer show that in many instances the polarization of the cake has increased appreciably, although the amount of cake was reduced about 25 per cent. This is, of course, due to the absence of the filter-aid properties of cush-cush. The characteristics of press cake are so variable that it may well be that any alteration in its make-up will have an influence in either direction, beneficial or otherwise. An interesting question is here presented in regard to the amount of sugar actually recovered by excessive washing. It is believed that down to a reasonable exhaustion, washing is justified by the amount of water used in sweetening-off, but after a certain point there is doubt whether the evaporation of the water pays for the extra polarization recovered, and whether there may not be a resolution of impurities from the cake which would more than offset the reduction in polarization. This is a point that is worthy of attention. There are no data available in which the purities of successive washings of the presses are given. It is realized that this would be a difficult problem, principally because of the low density of the last runnings.

Another result of fine straining will be additional fuel, in the form of bagasse, the amount removed varying with the variety of cane being ground, the preparation of the cane before crushing, and the condition of the Messchaert grooves, scrapers, and returner bars, and also on the size of the perforations of the mill strainer. Tests at various places have shown that of the total suspended matter in the raw juice from 15 per cent to 46 per cent is taken out by fine screening. Assuming that the screen removes 30 per cent it is found that with .50 per cent suspended matter on mixed juice, there is removed the equivalent

of .25 per cent bagasse of 40 per cent moisture, on mixed juice. It seems fair to give this removed material the value of bagasse, as it is mainly organic matter, the finest particles, such as silt and soil, being taken out to a much lesser extent.

An advantage from fine straining which is not computable in dollars and cents is the easier cleaning of heating surfaces. With the removal of relatively large quantities of organic matter, there is less left to accumulate on the tubes of heaters and evaporators. The advantage is quite evident particularly where the cane is dirty from adhering soil. In cases where the cane is fed to the mill as in flumed plantations, there will likely not be a compensating advantage.

It is certain that theoretically there should be a real advantage in the fine straining of raw juice, and it may be that with better acquaintance with these new conditions we will find that practice will agree with theory.

Calculations of Savings Due Strainer

Assume a factory handling 100,000 tons of juice per season. At Hawaiian Commercial & Sugar Company, laboratory tests have shown that 0.4 per cent of dry suspended matter is removed from the juice. McBryde gives .15 to .40; and Los Mochis reports 0.3 per cent. Taking 0.3 per cent: 100,000 tons juice at 0.3 per cent = 300 tons dry matter. At 45 per cent moisture, this is equivalent to 545 tons bagasse. With one ton bagasse equal in fuel value to a barrel of oil, at present value of oil ($1.50 per barrel), this is worth $817.00.

Press Cake Losses: Assuming that press cake amounts to 2 per cent on juice and contains 3 per cent polarization, a reduction of 25 per cent weight of cake with same polarization is a saving of 15 tons sucrose. Assume 80 per cent recovery as 96 test sugar: this equals 12 tons of sugar, worth, at $80 per ton, $960.

Molasses: Starting with a syrup of 85 purity and ending with a sugar of 96 polarization, 97 purity, and a final molasses of 38 gravity purity, assuming 12 per cent polarization in juice, a reduction of 1 degree purity in the molasses corresponds to a gain of 48.35 tons 96° sugar, worth at $80 per ton $3868.

Syrup: If besides the decrease in molasses purity of 1 degree, the syrup purity is raised 0.2 per cent, the extra recovery as 96 sugar will be 69 tons, worth $5520.

Extra Expenses: There must be allowance made for interest and depreciation on the apparatus, say at 20 per cent, $500; and replacement of the fine screen, say, three times in the season at $120, or $360. There may be an extra cost for lime; if this amounts to 25 per cent, which is extreme, the additional expense will be about $300 for this material. We then have:

Fuel value bagacillo	$ 817.00	
Press cake savings as sugar	960.00	
Sugar from lower molasses and higher syrup	5,520.00	$7,297.00
Depreciation, etc.	$ 500.00	
New screen	360.00	
Additional lime	300.00	1,160.00
Possible net gain		$6,137.00

These conditions are probably ideal and will not be realized in practice, but there is sufficient margin to warrant the trial in any factory where there is need of improvement in quality of clarification, quality of sugar, or such other operations as cleaning of heating surfaces, to which a value cannot be given with any degree of accuracy.

The following are extracts from reports received from factories which have used the Peck strainer during the past crop.

Mr. Norman King, Chemist at Koloa Sugar Company, writes:

I hesitate to say too much one way or the other until we have had more experience with the Peck fine juice strainer. An average covering a period of five weeks before and five weeks after the installation discloses the following results:

	Before	After
Press cake per cent cane	3.30	2.30
Polarization per cent cake	2.07	3.15
Polarization cake per cent cane	.0683	.0724
Moisture per cent cake	74.76	79.49
Dry non-sucrose per cent cane	.765	.399
Lime, pounds per ton cane	1.67	2.45

Any effect on low grade work was lost in the presence of higher juice purities and the recent installation of a No. 2 massecuite mingler, for the purpose of mixing water into the low grade massecuite prior to drying. It can be said, however, that the quality of work at this station was conspicuously improved.

The McBryde Sugar Company has had a Peck strainer equipped with a 100 mesh screen in operation since January 14, 1924. Contained in a recent statement from this factory are the following:

Immediate Results: After installation the suspended matter dropped to less than 0.1 per cent on mixed juice.

Effect on Press Cake:

	To January 14	After
Cake per cent cane	2.16	1.66
Polarization per cent cake	2.41	2.33
Polarization in cake per cent cane	.053	.039

Increase in Purity: Up to January 14th the increase in purity averaged around 1.1; for seven weeks with the strainer it averaged 1.68.

Evaporators: After the installation of the strainer there was a noticeable improvement in the "cleaning evaporators" item. The scale was light and easily removed.

Fuel Value: The removed bagacillo was equivalent to about 250 tons of bagasse.

Drop in Waste Molasses: The reports show a gravity purity of molasses to and including January 12th of 39.36, and to April 26th of 38.34. There is a drop of one point, part of which should be credited to the strainer.

Mr. B. B. Henderson, of Lihue, writes in part:

On May 1st of this year a Peck strainer was installed in the Lihue factory. No mechanical difficulties were experienced. A weekly cleaning of the screen with hot caustic soda solution was sufficient to keep it functioning properly.

The results of fine screening are not easily arrived at. A new juice was delivered to the boiling house and it is possible that this affected every station and product in the house. These effects might be classified in two ways. First, as results that appear on the factory reports, and second in the working of the products.

Under the first classification the following appear:

	April	May	June	July
Cake per cent cane	2.23	1.75	1.80	1.75
Cake polarization	1.13	3.29	3.49	2.76
Polarization in cake per cent cane	0.025	0.058	0.063	0.048

The results to be recorded under the second classification are far more difficult to arrive at than the first. However, the following is stated: the result of fine screening had no apparent effect on the work at any station that could be observed in the course of manufacture, with the exception of the presses, where at first it was impossible to get a cake. This difficulty was overcome by heavy liming and there was no clogging of the mud lines as sometimes occurred before the removal of cush-cush.

The only results that can be definitely attributed to the removal of cush-cush from the raw juice at Lihue during the 1924 crop are as follows:

1. Double the loss of sugar at the press station.
2. Difficulty at this station overcome by heavy liming.
3. No clogging of pipe lines carrying settlings.

In conclusion, the writer wishes to emphasize that this report is based on the work at one factory covering only a short length of time. Fine screening is to be continued.

At Kahuku, the fine screen was operated during alternate months in an attempt to ascertain, in a practical way, what results could be attributed to the strainer. Unfortunately, our settling tank capacity was under par so that a cycle of less than one hour was not uncommon. This handicap no doubt rendered further comparisons in boiling house work almost useless, since it is obvious that ample settling capacity is essential toward a maximum increase between mixed juice and clarified juice, and, to a similar extent, in the handling of low grade products. It may then be due to the above cause that we report no noticeable difference due to fine screening, either in our factory operations or our laboratory reports, mud presses excepted.

No great difficulty was experienced in getting a good press cake from fine screened juice. Closer supervision at this station was necessary, however, special care being taken in regard to liming, the time in filling and the proper time of washing the presses. Mud press data for the first six months of the 1924 crop are as follows:

	Press Cake per cent Cane	Cake per cent Polarization	Pounds Lime per Ton Cane	Pol. in Mud per cent Cane
Fine screened juice	2.04	3.71	2.23	.076
Ordinary screened juice	2.60	3.04	1.57	.079

Mr. Lougher, Factory Superintendent of the Hawaiian Commercial & Sugar Company, reports:

The value of the Peck strainer is observed in its use for removing the enormous amount of finely divided bagasse, or cush-cush, passing through the mill strainers. The benefits obtained by its removal may be enumerated as follows:

1. Its use in conjunction with the Petree Process is ideal, giving a decreased amount of material to be returned to the mills from the clarifiers, consequently a better extraction and increased fuel.

2. There is a decided increase in the capacity of clarifiers, better clarification, better quality of sugar, lower molasses losses, and lower costs, besides assisting in removing the media that finds its way into the sugar crystals, producing and assisting propagation of bacteria, causing inversion and sugar loss.

3. The extraction of gummy substances from the cush-cush due to the action of heat and lime is avoided; hence, better working products throughout the house. This is especially noticeable in the drying of low grades.

4. The accuracy of control is greater, due to elimination of cush-cush which is otherwise weighed as juice. The figures "bagasse per cent cane" and "tons juice entering boiling house" are more nearly correct.

5. By proper treatment of settlings a press cake can be obtained which will contain only a fraction of the sugar lost at this station when the cush-cush is allowed to enter the boiling house, as only a fraction of the volume of solids is present to be filtered.

6. I will state that all the finely divided suspended matter removed by the Peck strainer will prove a valuable aid to the installation of Kopke separators now being erected, in that the absence of this matter will mean greater capacity by increasing the time of cycle due to the decreased volume of solids to be removed.

I would stress one important advantage of this system of straining the juice. After periods of very rainy weather the cane comes to the factory with large amounts of soil sticking to the cane stalks, adventitious roots, and unburned leaves. This finds its way naturally into the juice and eventually to the presses, and is one of the principal causes of difficulty in filtration. The strainer removes not all but a considerable amount of this unwelcome material from the process, and under such conditions makes for an immediate improvement at the press station.

Another point has been raised as to the possibility of increasing amounts of bagacillo being returned from the mills until more is delivered to the strainer than it can handle; this has never happened at Kahuku. It would appear that the fine material returned to the mill is retained by the bagasse blanket, and a uniform amount regularly dropped into the juice.

In conclusion, the writer would state that during the next season the strainer will be operated off and on during definite periods, so as to obtain more precise information as to the effect on the work of the house.

Plantation Railways and Equipment*

By E. W. Fahlgren

The railway system of a plantation, which uses this means of transportation, is one of its most important units, although in many cases it does not get the same careful consideration and attention as do other units of equal or lesser importance. A fine, big, up-to-date and highly efficient crushing plant and boiling house, with tons upon tons of the finest cane grown, is of little use without adequate means of transporting the cane to the mill and the raw sugar from it.

Railway transportation is unquestionably the most efficient means now in use for transporting heavy loads of any kind. It has numerous advantages, chief of which are reliability, standardization of equipment and component parts, and comparative ease in training men to operate. There are also some disadvantages, the two main ones being the difficulty of surmounting steep grades and negotiating sharp curves.

The work of locating railway lines gives many opportunities for engineering ability of the highest order. The locating engineer should first ascertain the

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amount of money available for construction purposes, the probable amount of traffic, general nature of rolling stock to be used, approximate amount of mileage that will be required, including mill yards, branches, and sidings, and the gauge of track. The gauge of track plays an important part in the locating of lines and should be given considerable thought.

In selecting a track gauge, first consideration should be given to the gauge of any already established commercial railway which would act both as a feeder for incoming supplies and as an outlet for sending raw sugar to the port of shipment. If there is no such railway, then consideration should be given to the gauge of other plantations in the vicinity as inter-connecting railway lines are sometimes very useful. Care should be taken in such cases, however, as the gauge may be one that is too narrow for efficient operation of rolling stock.

The standard gauge of the United States is 56½″ and plantation gauges run from this down to 20″. Plantations in Cuba use the 56½″ gauge, as they operate cane cars of 30 and 40 tons capacity with eight wheels under them, the small 5-ton, 4-wheel car being almost unknown. In the Philippines two gauges only are used, 36″ and 42″; only one Central has a smaller gauge. Brazil uses mostly the meter gauge, 39⅜″. Here, in Hawaii, we have 56½″, 36″, 30″ and 24″. The 36″ gauge predominates on most of the plantations and this gauge has become known as "the standard narrow gauge" among manufactures of narrow gauge equipment.

Carl B. Andrews, in his article on "Transportation" in the *Planters' Record* of 1918, gives the advantages of narrow gauge railways over the standard gauge as follows:

1. Lower original cost, because of the smaller dimensions of rolling stock, requiring narrower cuts and fills and light track, and, because of the possibility of using sharper curves, the ability to fit the line to the terrain closely.

2. Because of the possibility of sharp curves, it is easier to take the track into close quarters near mills, etc.

Among the disadvantages he mentions:

1. The impossibility of changing the gauge to standard after a narrow gauge has been once adopted, without great cost.

2. Delay in obtaining from manufacturers of rolling stock, material, locomotives or cars which differ from the accepted standard.

3. Limitation of carrying capacity because of small locomotives and cars.

The writer agrees with Mr. Andrews in his statement of the advantages of the narrow gauge, but does not agree on all his disadvantages under present manufacturing conditions. The first mentioned disadvantage is, of course, a real one, but it need hardly be considered, for, after a plantation has once adopted a gauge, say of 30″ or 36″, there is hardly any likelihood of their changing it to the standard gauge of 56½″.

The second disadvantage does not apply today, as there are any number of reliable manufacturers of locomotives and cars who specialize in narrow gauge equipment. Some of them carry large stocks of narrow gauge equipment in the various sugar-growing countries. There is a delay in manufacturing some items of narrow gauge equipment, but this applies as well to standard gauge or any

other accepted standard, for no manufacturer keeps locomotives and cars on hand ready to be shipped at a moment's notice, unless it is second-hand equipment.

The third disadvantage still exists but is practically negligible, for none of our local plantations are handicapped by inability to haul their cane to the mill on account of the narrow gauge. If they are handicapped at all, it is through lack of necessary equipment for hauling.

After the above digression the writer will get back to the locating of the railway lines. The locating engineer, having all the foregoing information in his possession, is now in a position to begin his surveys. He should first carefully look over the country surrounding the plantation and ascertain roughly where the railway lines will have to run, ever keeping in mind the necessity of obtaining as low grades as possible even adding a reasonable distance to his line to accomplish this. After doing this, he should start his actual surveys, commencing at the mill site, or from a point where the mill yards will commence. When the line is once permanently located, cross-section work should start so that grading may begin.

Fills should be made wherever possible with a width of 12 feet on top, so that there may be 3 feet clear on each side of track outside of ties. This provides a space for unloading ballast without waste, gives room to walk alongside of a loaded train, and often saves bad wrecks by preventing derailed cars from rolling down an embankment.

Cuts should be laid out to give at least 14 feet in the bottom so that a 2-foot ditch can be made on each side to drain water from the cut.

Drainage is an important factor to consider. Openings provided with ditches leading to them should be put through the grade at all places where water is likely to accumulate and damage the track. If a culvert is to handle this, it should be put in while the grading is being done. Culverts may be of square concrete, concrete pipe or corrugated galvanized iron pipe. A concrete head should be put on to keep the water from washing around the pipe.

Bridges should be of ample length to take care of flood waters. Short spans can be built up very cheaply by using concrete piers and standard I beams. Wide spans, from 20 feet up, should have steel girders or truss construction with concrete piers or abutments. Hard wood may be used in bridge construction, but steel will be cheaper in the end if given proper attention.

Crushed rock makes the best material for ballasting, although sometimes it is possible to obtain river gravel mixed with sand which makes a very good ballasting material.

As curves is one of the chief factors in limiting the tonnage hauled over a railway, it is well to give them careful thought. Due to the many factors involved, it is impossible to give an exact rule for computing the resistance due to curves of any given radius. It is generally considered, however, that the resistance amounts to from .7 of a pound to 1 pound per ton per degree of curvature, the lower figure being used for large capacity cars and the higher figure for smaller capacity cars, as in the latter case there are more wheels and axles per ton of weight than in the former.

The sharpest curve to which two pairs of flanged wheels will adjust themselves, depends upon their distance apart, the diameter of the wheels, and the size and shape of the flanges.

Taking the Master Car Builders standard for flanges and rails and assuming that the gauge is not widened on the curves, a sufficiently accurate formula for all practical purposes is as follows:

$$R \frac{W}{2 \sin a} \text{ in which}$$

R = radius of the sharpest curve that can be passed,
W = wheelbase of car or locomotive,
a = angle the flanged wheels make with the rails.

The minimum radius advisable for plantation use may be taken as about 175 to 210 feet, although in a great many cases a smaller radius has to be used.

The outer rail on all curves should be elevated and the amount of this elevation may be determined from the following formula, presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association in 1905:

$$E = .00066DV^2,$$

where E = elevation of outer rail in inches,
D = degree of curve,
V = velocity of train in miles per hour.

Since the elevation required is a function of, and depends upon, the train speed, this speed is the first element to be determined. Ordinarily an elevation of 8″ is not exceeded and speed of trains should be regulated to conform to that elevation.

At the 1919 convention of the American Railway Master Mechanics Association the committee on widening gauge of track at curves recommended as follows:

Curves 8 degrees and under should not have the gauge widened. Gauges should be widened ⅛″ for each two degrees or fraction thereof over 8 degrees to a maximum of ¾″. Gauge, including widening due to wear, should never exceed 1″.

Grade is the other chief factor that controls the tonnage that can be moved by a given power over the railway. The maximum grade must not exceed that up which the power to be used may haul the desired load to be taken up; also the grade must not be so great that the braking power used will be insufficient to stop any downcoming train within a reasonable distance should necessity require.

When a train is hauled up a grade, the resistance due to friction is increased by that due to lifting the train against gravity. The amount of this increased resistance is determined as follows: One mile equals 5,280 feet, and, if the grade be one foot per mile, the pull necessary to lift a ton of 2,000 pounds will be 2000/5280 equals .3788 pounds per ton of 2,000 pounds; the rise in feet per mile must be multiplied by .3788.

If the grade is expressed in feet per hundred or per cent, the resistance in pounds per ton of 2,000 pounds will be 2000/100 equals 20 pounds for each per cent of grade.

To resistance so obtained must be added that due to speed and internal friction in order to find the total resistance in pounds per ton. In the cases of standard railroad cars and the average plantation car using brass or bronze bearings the frictional resistance can be safely figured at 10 pounds per ton of load.

Until just recently too little attention has been paid to the size and weight of rail used for track. Of course, when the majority of our plantations were started, years ago, their locomotives were much smaller and lighter than those of today. Considerable money could have been saved, however, by originally laying heavier iron rails, which were easily and cheaply obtainable in those days.

The average steam locomotive for plantation use today weighs from 15 to 20 tons, and for such locomotives nothing less than 35-pound rail should be used. Forty or forty-five-pound rail would be preferable, as these weights would better bridge over a rotten or broken tie and stand up over soft places without kinking.

In the purchasing of light steel rails there are three kinds to be considered. By light rails is meant those weighing 60 pounds per yard and less. The differences are as follows:

1. "Billet rolled" rails.
2. "Re-rolled" rails.
3. "Re-laying" rails.

"Billet rolled" light steel rails are marketed under no definite specifications regarding the quality of the steel that is used in their manufacture. The result is that this opens up great possibilities for the large primary steel mills (manufacturing "diversified" products) to roll into light section steel rails their accumulation of steel representing off heats or discards, or that spongy portion of the billet which railroad specifications oblige them to eliminate in rolling standard heavy steel rails. It is obvious, therefore, that such mills naturally turn to light steel rails in the effort to utilize such discarded steel that would otherwise have little more than scrap value.

"Re-rolled" rails, it must be understood, are made from standard heavy steel rails and the raw material of the re-rolling mill consists of these heavy section tee rails, ranging in weights from 60 to 136 pounds per yard, which have been taken up from various tracks because their years of service have caused them to wear to such an extent as to make them unusable for further active railroad service in that location, or possibly because they were to be replaced by heavier rail sections due to increasingly heavier traffic. These rails, having been used by the largest railroad interests in this country, were, at the time of their installation, subjected to the most rigid tests covering their chemical and physical qualities.

The rails upon being received by the re-rolling mill are subjected to a preliminary inspection, after which they are broken into such lengths as may be necessary for the manufacture of the new light section rails. This breaking process affords just the opportunity necessary to detect pipes, flaws, or improper molecular construction, as well as other defects which sometimes exist even in a

new heavy rail. Such material, of course, is immediately discarded as unfit for use, for, if an attempt were made to roll it, the defect would become more apparent, resulting in a cobble or scrap rail suitable only for resmelting purposes.

The rails are then charged into a furnace where they are heated to the proper rolling temperature, and from this stage the process of manufacture is identical with that employed by primary rail mills; that is, the heated rail receives the necessary number of passes through the rolling mill to reduce it to a given cross section required for a light rail ranging in weight from 8 pounds to 60 pounds per yard inclusive. After the rail has gone through the finishing pass, it is hot-sawed to the desired length, cooled, straightened, punched for splice bars, and finally passed on to the inspection department where a rigid inspection prevails, with the result that all "A" number one materials receive the classification of "New First Quality" and number two material receives the classification of "New Second Quality," and under these classifications is ready for the market.

This re-heating and re-rolling process overcomes entirely any crystallization which may have occurred in the old rail by reason of its previous service and fully restores it to its original strength and character.

Proof of this lies in the fact that, consistent with the well-known law, the more that steel is re-heated, re-rolled, hammered, or otherwise worked, the finer will be its quality.

Summarizing: we find "Billet Rolled" light steel rails are, for the most part, rolled from offheats, or discards, or from steel which proved inferior for the purpose for which it was intended. Rails rolled under the "Re-rolling" process are manufactured from steel made expressly for rail purposes which has stood the full test required in such use.

"Re-laying" rails are secondhand rails which have been used and taken out of service for any number of reasons. Such rails should never be bought unless an exceptionally favorable price is offered and a rigid inspection made at time of purchasing.

Rails that have been in use for some time should be replaced when the splice bars are being chipped by the wheel flanges, when the side of head is worn as much as ⅛″ the original width, or when the side of the rail head is worn to the shape of the wheel flange and fillet.

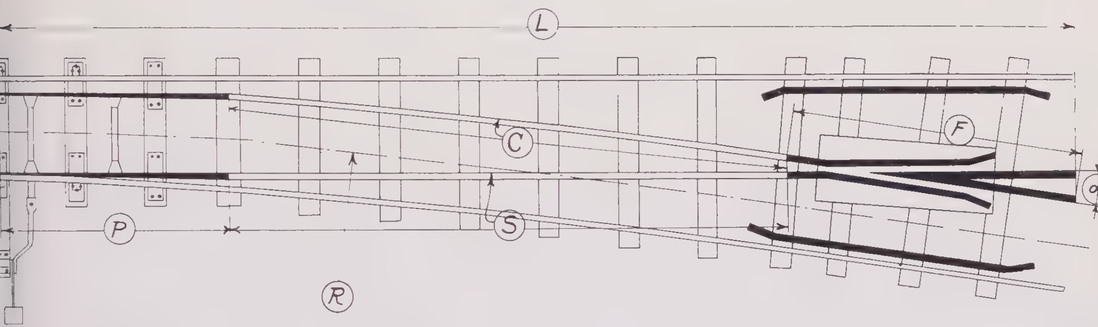
Ties should be at least 5″ by 7″ by 6′, hard wood preferred. Hewn ties are always the best if obtainable, as bearing surface is what is wanted and this is more readily obtained from hewn ties. Ties measuring 6″ by 8″ by 6′ are being generally used as a standard size. No uniform rule can be made for the spacing of ties due to the varying elements that govern this, such as sub-grade, depth of ballast, axle loads, etc., but 24″ center to center of ties has become somewhat of an accepted standard in track laying.

The nail-spike is the American standard for fastening rails to ties and these should be used four to each rail fastening or eight spikes to each tie. Passing trains produce a movement which gradually lifts the spikes out of the tie, but this causes no real danger to traffic provided the spikes are re-driven every so often by the section crew. A test made some years ago by prominent railroad engineers determined that the nail-spike was, in general, more efficient than the

screw-spike. Spikes should be driven straight, as a spike driven with a slant under the rail does not have the holding power of a straight driven spike.

Frogs should not be put in for branches or sidings when laying track, as this necessitates the cutting of rails later when the turnouts are laid. By using one pattern of standard frog all that is necessary afterwards is to open a joint, throw the rail out, and then place the frog. Thus a standard length of lead rail will always fit and it will be interchangeable with any switch on the line. If the joint does not fit the engineer's frog point, open the back joint instead of the front one and then compound the curve to fit the engineer's centers ahead. On sidings it can be moved ahead or back a few feet to suit the joint opened.

The following table will give characteristics of frogs having different numbers:



Frog Number	Frog Angle L	Radius of Curve R Feet	Length L Ft.	Length L Ins.	Length of Points P Ft.	Length of Points P Ins.	Length of Frog F Ft.	Length of Frog F Ins.	Length of Straight Filler Rail S Ft.	Length of Straight Filler Rail S Ins.	Length of Curved Filler Rail C Ft.	Length of Curved Filler Rail C Ins.
3	18° 55′	54	19	8	5	0	3	3	11	5	11	8 3/8
3½	16° 16′	74	22	9	5	0	3	6	14	3	14	6 1/2
4	14° 15′	96	25	11	5	0	3	9	17	2	17	4 1/2
4½	12° 41′	122	29	0	5	0	4	0	20	0	20	2 3/4
5	11° 25′	150	32	2	5	0	4	3	22	11	23	0 3/4
5½	10° 23′	182	35	3	5	0	4	6	25	9	25	10 15/16
5	11° 25′	150	32	2	7	6	4	3	20	5	20	6 3/4
5½	10° 23′	182	35	3	7	6	4	6	23	3	23	4 15/16
6	9° 32′	216	38	6	7	6	5	0	26	0	26	2 15/16
6½	8° 48′	254	41	9	7	6	5	6	28	9	28	11
7	8° 10′	294	45	0	7	6	6	0	31	6	31	7 7/16
7½	7° 38′	338	48	3	7	6	6	6	34	3	34	5
8	7° 09′	384	51	6	7	6	7	0	37	0	37	1 5/16
8	7° 09′	384	51	6	10	0	7	0	34	6	34	7 5/16
8½	6° 44′	434	54	9	10	0	7	6	37	3	37	4 1/2
9	6° 22′	486	58	0	10	0	8	0	40	0	40	2 1/16
9½	6° 02′	542	61	3	10	0	8	6	42	9	42	11 1/8
10	5° 43′	600	64	6	10	0	9	0	45	6	45	6 3/16

Particular attention should be given to the power used on plantation railways. By power is meant anything that moves the cars over the rails, be it animals, motors, or locomotives. Steam locomotives have been, and are yet, the most common source of power for plantation use, although motor-driven locomotives are coming to the fore, and our manufacturers of steam locomotives, for narrow gauge use, are giving considerable attention to this type of locomotive.

The hauling capacity of a locomotive depends primarily upon the weight carried on the driving wheels; hence it is important, in engines designed for heavy service, to utilize for adhesion as large a portion of the total weight as operating conditions will permit. The ideal locomotive, as far as hauling capacity is concerned, would, of course, be one having its entire weight, including that of fuel and water, carried on the driving wheels.

For plantation service it is not safe to assume that there is a standard type locomotive. A locomotive of certain type may give perfect service on one plantation, while on another plantation, where the working conditions are different, it would be an absolute failure. On the large American railroads there are certain types used for switching purposes, others for freight, and still another for passenger, but for plantations, where the service is all switching and freight with varying working conditions, there can be no real standard.

In figuring on a locomotive, do not go by what the other fellow has, but let your conditions of service be known to the locomotive manufacturer who will give you a specification which meets your requirements.

The cane cars as used on plantations are for the most part an entirely different proposition from locomotives and it is possible and advisable to standardize. There are two types of cars used on Hawaiian plantations having the same general construction, but with some deviations according to ideas of best service. Incorporated into these cars are parts or accessories, in some cases of no known standard and, where such conditions exist, the plantation, unless they anticipate their requirements, experiences delays in getting such material. All the manufacturers of narrow gauge railway equipment endeavor to standardize their material and none of them stock anything special. The majority of accessories in the make up of a cane car are standard with all manufacturers and if such is not exactly the case, they at least are interchangeable. When these standard parts are used the plantation does not have the delay in getting parts as they may be purchased from any one of the manufacturers represented.

The use of "side stake" and "side door" cars here is about equally divided. The "side door" car in the opinion of many is better adapted for loading "hapaiko" than the "stake" car, as runners may be rested on the top of the door and the loaders drop their bundle of cane into the car from this runner. The side door also acts as a chute into the carrier when the car is being unloaded. The advantage of this type car is its compactness, as it has no stake pockets or stakes to become loose or get stolen. One disadvantage, while not serious, is ever present, viz., the difficulty in releasing the side doors with the pressure of a load of cane on them. The present type of chain latches holding up the doors is very efficient in its function, but in the cane shed, they are sometimes too efficient in that they do not always easily release the doors. Considerable pound-

ing and hauling at the releasing rings is quite often necessary before they will let go. Several types of door latches have been tried out from time to time, but none of them has been a success. The most successful one is "The Boyum Latch," which is the idea of Mr. E. E. Boyum, and is used by Maui Agricultural Company. This latch consists of a flat steel bar running across the end of the car, bolted to end stakes and having a lug on each end. The chain part of the latch is fastened to the sidedoor with the usual eyebolt on one end, the other end having a link large enough to fit over the lug on cross bar. This link is held on the lug by a two-lipped lever, which is pivoted along the side of the lug. When the lever is in a vertical position, the outside lip holds the link in place on the lug and, when this lever is moved counter clockwise, the inside lip slips under the link and slides it off the lug. No pounding is necessary to release this latch and at the same time it holds the door securely in place.

The stake type car has its adherents, but they all admit the disadvantage of having the stakes lost or stolen. The loss of stakes runs quite high each year. It is surprising how quickly nicely cut stakes can disappear from a car. This loss runs so high in some places that old boiler tubes and rough cut "kiawe" limbs are being used for stakes. It is also quite necessary with the stake car to have stake pockets that firmly hold the stakes in position and that are easily released with the pressure of the cane against them. Several different types of releasing pockets are now being used, all of which seem to be giving a fair degree of satisfaction. Some plantations make side racks for use with this type of car in which case the stake pockets are the solid type and the racks are lifted, more often torn, from the car by means of a hoist in the cane shed.

Neither of the foregoing types of cars, as designed at present, is particularly well adapted for use with the loading machines. The bundles of cane as they are dropped into cars, spring the end walls out and in time these break off. As the loading machines are here to stay, the writer can promise some interesting developments in car design and unloading devices in the near future.

The most economical type of car for hauling cane would be the large 30-ton double truck cars as used in Cuba. Six 5-ton cars will carry no more cane than one 30-ton car, but these six cars not only have 50 per cent more axles and journal boxes, but their maintenance is a serious item in operation costs. The larger car could not be operated on portable track and as most of the Hawaiian cane is transported this way, the large car is out of the question for general use.

The all steel type of construction in small cane cars has never been popular in Hawaii, and this unpopularity in the main can be laid to two causes: First, because a large portion of our cane fields are on hillsides or high elevations, which means steep grades with the ever-present possibility of wrecks; second, because of the light construction of the steel cars; they could not stand being wrecked and, once they had been wrecked, they were in most cases so bent and twisted out of shape that it was hopeless to try to straighten and salvage them. Today, however, the steel cars are being designed differently so that they will withstand very severe operation usage. End sills are of steel plate, bent U-shape and riveted to top and bottom flanges of all long sills. The entire frame is covered with steel plate which is also securely riveted to all sills which makes a very rigid

construction. This car will some day come into its own, as the maintenance will be so much less in comparison with the wooden construction.

The maintenance and repairs to rolling stock is a very important item in operating costs and in the efficiency of the cars themselves. For this reason a simple form of record should be kept of the repairs made on each car so that the amount of time and money spent may be known. A system should be worked out so that the cars in every train as it comes from the field can be inspected and cars needing any repairs marked so that the trainmen will put them on the repair track. This sounds like a big contract, but one man can walk alongside the train as it moves into the cane shed track and mark the cars needing attention. It is far better to do this than to let a car go until something serious happens to it. The nuts on draft rods should be tightened at the least sign of slackening. Do not let this go until the couplers sag off center, for if they do the couplers themselves will be broken or the threads stripped off the draft rods, allowing the couplers to pull off, which may cause a serious wreck.

Pedestal brace bolts should always be kept tight and brake pins and gear kept adjusted, as brakes are put on cars for a purpose, and a few poorly adjusted brakes on a train can cause no little trouble besides endangering the lives of the brakemen. Stake pockets, hinges, and hinge butts should never be allowed to become loose. Journals should be lubricated at regular intervals to prevent hot boxes. This is one feature of maintenance that quite often receives too little attention. For packing in journal boxes it is well to use a good grade of wool waste, although there are several substitutes for wool waste being used with very satisfactory results. Shredded burlap makes a good packing and is being used by some plantations throughout. In the Philippines where sponges are cheap and plentiful they are used with a fair degree of success. Coconut fibre is also being used and from the latest reports is proving a very good substitute.

In packing journal boxes, the waste or whatever is used should be submerged in oil for about 48 hours, endeavoring to keep temperature of oil approximately 30 degrees C. during the entire time of soaking. The surplus oil is then drained off, allowing sufficient to remain to approximately equal 5 pints of oil per pound of dry waste or substitute. The packing placed in a journal box first should be in the form of a twisted roll, pressed out moderately dry and packed tightly around the back end of the box, for the purpose not only of retaining the oil, but also better to exclude dust and dirt.

After this is done proceed to pack the box with loosely formed packing sufficiently firm under the journal to avoid settling away, which is caused by shocks when the car is in motion. Pack it more lightly on each side of the journal to avoid the wiping effect, produced when waste is pressed too tightly between the journal and the side of the box. Height of packing should not extend above center line of journal and not beyond inside of collar.

The portion of packing placed between end of journal and front end of box, being the last put in, should have no thread connection with the packing under or on side of journal, and should not extend more than one-half inch above lower edge of collar. This packing affords no means of lubrication to the jour-

nal, but prevents packing on sides and under journal from working forward out of normal position for satisfactory service.

The most important part of the work for successful lubrication is intelligent attention to the packing in boxes on equipment in service and briefly consists of lightly loosening up the packing on each side of journal to avoid the hardened and glazed condition, which is caused by the packing remaining too long in direct contact with journal. This work can be effectively accomplished by the use of a good tool which should have a V-shaped end. No attempt should be made to raise the whole body of packing in the box, as is sometimes practiced by means of tools with square or blunt ends.

Attention should be given to equipment at frequent intervals or at such time as the condition of packing will indicate it to be necessary. Oil should not be added to journal boxes until the condition of packing is ascertained to require it, avoiding the excess use of oil as evidenced by the accumulation on the wheels and outside of boxes. When using the oil can, oil should be placed on side of journal, and when saturated packing is used as a lubricant it should be placed in contact with journal. Cars in shops for repairs should have packing removed, repicked, and replaced. This work need not be done at closer intervals than twelve months, the object being to maintain an elastic condition of packing.

Brasses should not be transferred from one journal box to another, and before applying suitable sized brasses, the journal and the surface of brass should be oiled. A new close-fitting dust guard should be applied in all cases when renewing wheels and when practicable after a hot journal has occurred.

For the lubrication of journals by trainmen, saturated packing only should be furnished; all packing removed should be returned to points where it is prepared for distribution.

The accessory business for railway equipment has become almost like the automobile accessory business in the number of different ideas for parts, but, unlike the automobile business, the ideas offered are not so freakish in design. Car couplers show perhaps the most numerous of varied designs and ideas. The spring type coupler offers the best field for improvements, as it is generally conceded that this type of coupler is the best, in that it is the easiest on cars on account of absorbing all buffing and pulling strains. The majority of these types of couplers now have the links and pins fastened in the head, preventing these two parts from getting in with the cane and going through the rolls.

Wheels, perhaps, next to couplers, show a wide variety of designs. In Hawaii the spoke type wheel has always been the most popular, due, no doubt, to the ease of braking cars by throwing a stake between the spokes. Cast steel makes the best material for plantation wheels, although one or two or our plantations are using and getting good results from solid cast iron wheels having well-chilled treads. A properly designed steel plate wheel can be made lighter in weight and with less chance of the treads giving away than a spoke wheel. This is due to their being supported around the entire circumference. Spoke wheels are today being designed with enough weight so that there is little likelihood of their treads giving away between the spokes. Most of the damage being done to wheels today is from flat spots on their treads caused by the locking of brakes so that

the wheels slide along the rails. Some brakemen have the idea that brakes are not holding unless the wheels are sliding, which idea is not only erroneous, but disastrous. Wheels are worn flat in spots and, in case of wet rails, there is the possibility of cars running away, which almost invariably results in wrecks. Wheels should have good wide treads and full, well-rounded flanges; the latter to prevent catching in frog and switch points.

Cast steel is coming more and more into use as material for car parts, and before long all such castings will be made of this material. The most distinct change to cast steel, for plantation use, during the last two years, has been the making of brake shoes from steel. We have had brake shoes with steel backs and with steel inserts, but never a shoe made entirely of steel. Brake shoes have always been made of cast iron and will probably continue to be so made for general use. Iron shoes are easier on wheels, as the shoe wears instead of the wheel. The disadvantage is, that the lugs for holding shoe to head are easily broken off. Steel shoes have the advantage of permanent lugs, but they are hard on wheels. In spite of this, however, they are being used with great success on several plantations which have very severe grades, and here it is claimed that the steel shoe holds better than the iron one, even though the wheels are worn, and that fewer wrecks have occurred on that account.

A Method of Handling Cane Tassels for Breeding Work

By J. A. Verret, in collaboration with Y. Kutsunai, U. K. Das, Raymond Conant and Twigg Smith

During the present breeding season we developed a system of handling cane tassels for breeding which gives promise of being of tremendous help in the work of crossing and selfing cane varieties.

None of the methods used heretofore were wholly satisfactory. Emasculation is, of course, out of the question. The bagging method, the method mainly used in this work when accurate results were desired, is not satisfactory for several reasons. If cloth heavy enough to prevent the entrance of foreign pollen is used the shading seems to weaken the tassel greatly and poor or no germinations result. If the cloth is too light one has no assurance that other pollen has been kept out, so the object of the work is defeated.

On account of these unsatisfactory results the majority of cane breeders working on a large scale have resorted to the so-called "tying-on-of-tassels."

All breeders are familiar with the details of this method and we shall not describe it. It involves a great deal of work requiring the continuous change of tassels and, of course, no great protection against foreign pollen. Under the best conditions the cut tassels soon die. So in order to have good fresh pollen on the stigmas in their most receptive stage some breeders change these tassels in the night, generally from 2:00 to 4:00 a. m.

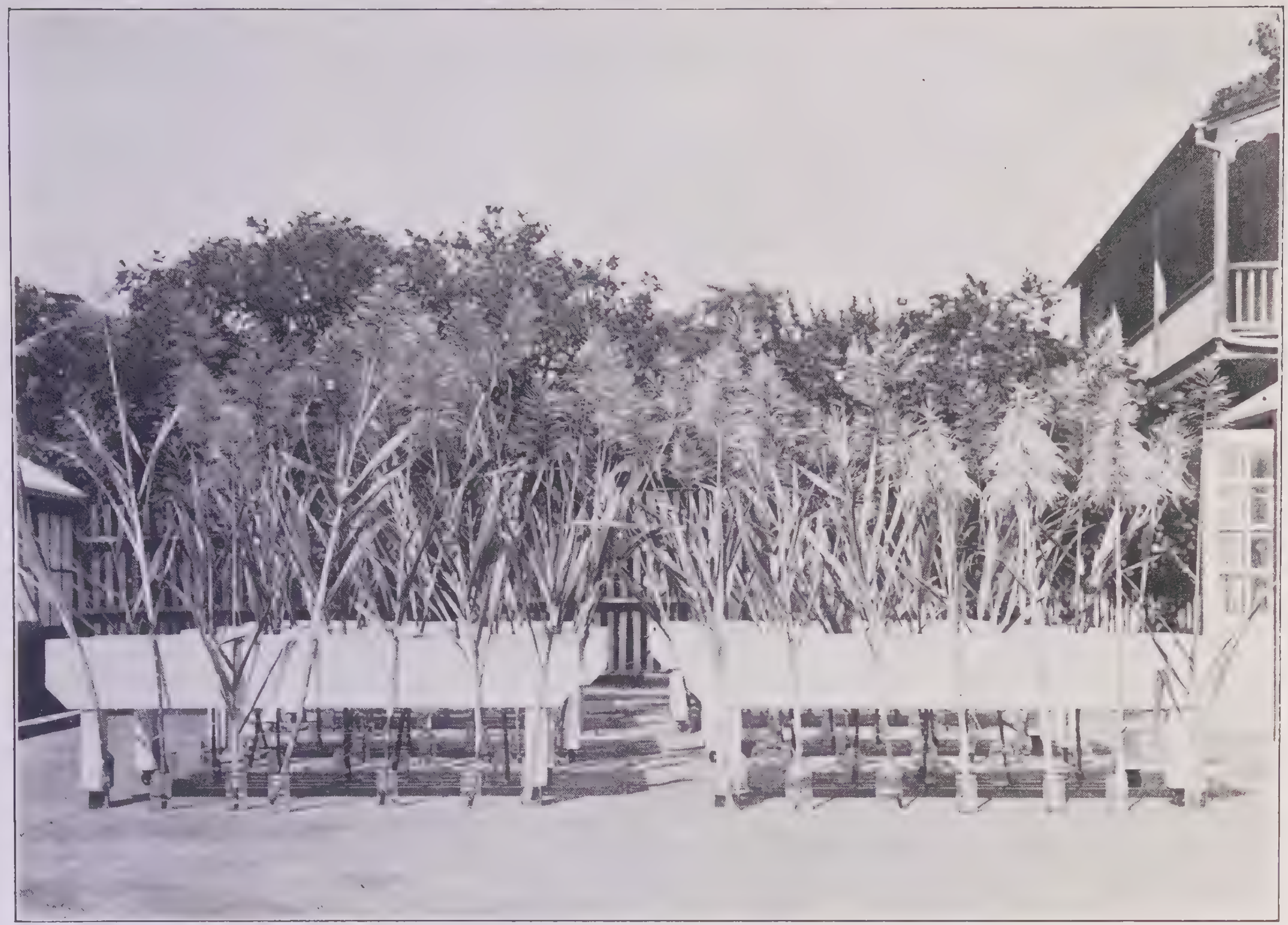


Fig. 1. General view of tests with the various solutions being tried. Such a layout can also be used for selfing or crossing if properly protected from foreign pollen.

Our method consists of the use of a certain solution which keeps the cut tassels fresh and developing normally for a long period of time. The method is not by any means perfected yet, as we have but recently started its use on cane tassels. But we feel that by making it public now other breeders can do work with it and in that way hasten its perfection.

After conducting a large number of experiments (one hundred or more) with all kinds of preservatives and other solutions we found that by placing the cut end of a cane stalk, with or without a tassel, in a solution of sulphurous acid (SO_2), 1 part in 2,000, it will keep alive, in apparently normal condition, for several weeks. After being once placed in the solution no further attention need be paid to the tassel except to see that it does not grow beyond reach of the tassel to be pollinated.

Microscopical examination of pollen from tassels cut from one week to ten days shows no differences from pollen from fresh tassels. We have obtained germinations from pollen taken from a tassel cut five days before, as shown in the following record by C. C. Barnum, of the Pathology department:

TASSEL CUT NOVEMBER 7, 1924

On November 11—pollen collected 12:00 Noon—germinated
On November 12—pollen collected 1:00 P. M.—germinated
On November 12—pollen collected 4:00 P. M.—germinated
On November 13—pollen collected 8:00 A. M.—germinated

TASSEL CUT NOVEMBER 17, 1924

On November 20—pollen collected 9:00 A. M.—germinated
On November 20—pollen collected 4:00 P. M.—germinated

It is very difficult to get cane pollen to germinate under any conditions so the getting of these germinations of pollen from cut tassels shows the pollen to be good.

Showing that the cut tassels kept in the sulphurous acid solution develop normally we have the following:

On October 21, three tassels were cut at the Manoa substation (these were the first tassels of the season) brought to the main office and placed in the solution at once. When cut, the tassels had not fully emerged and no stigmas or pollen sacks were out. These tassels were of the same variety and were kept isolated in a greenhouse. On November 6, the tassels had matured and the fuzz was planted. On November 12, we obtained germinations.

These results offer great possibilities in crossing and selfing work. If tassels so handled give good germinations it will be a simple matter to so isolate them as to be sure no other pollen has contaminated them.

In our work with the sulphurous acid solution we have found there are several things to be especially guarded against. One is to be sure that the sulphurous acid solution does not contain sulphuric acid. This may be the case with old solutions which have been exposed to the light. If any sulphuric acid be present the work will result in failure.

The next precaution to take is to have a solution of the proper strength. The solution should be strong enough to prevent turbidity but not be so strong as to burn the leaves. In other words, use the weakest solution that will prevent turbidity. We find a 1 to 2,000 freshly prepared solution to be satisfactory. It is possible that it can be somewhat weaker than this.

We find it more satisfactory to prepare our solutions ourselves with SO_2 gas. We prepare a 5 per cent SO_2 solution by slowly bubbling the gas through water. This is diluted as we want it, 1 cc. to 100 with water. Fresh stock solutions are made every week or so.

Another precaution for successful work is to place the tassel in the solution at once. When getting tassels some distance from headquarters, the cut ends are put in water immediately after cutting. On arrival where they are to be used, one joint is cut off under water and then the tassel goes to the solution at once, where it must remain continuously. Unless this is done failure generally results.

We leave from 2 to 4 feet of cane stalk with each tassel. The sugar in the stalk apparently is used for food by the plant in the solution, as at the end of two or three weeks or in some cases longer, there is no sugar left in the stalks.

The methods in use here previously and the various steps that led to the development of the new method are given briefly in the following paragraphs:

Heretofore in our work here the pollen-bearing tassels of sugar cane for artificial pollination have been obtained some distances away, brought to the station grounds, and treated somewhat as follows:

The lowest joint was cut away under water. The tassels were transferred to a container with clean water, taken to the female tassels or left leaning on a table so that the pollen grains could be utilized. The water in which the tassels were left standing was changed once or twice a day.

The changing of the water was found rather difficult in some of the high cages, and sometimes the waste water was poured accidentally on important tassels. To obviate this difficulty experiments were started to find a method suitable for keeping cut tassels alive and growing for say a week to ten days without changing water.

The drying of the cut tassels was thought to be due to clogging up of tubes through which water was taken up or by toxic substances in the water. This clogging could be brought about by some organisms in the water or in the cane stalks, by the suspended matter in the water, or by some decomposing material of the sugar cane itself.

From past experience, it was suspected that the growth of some sort of organisms in the water was responsible for the early death of cut sugar cane, and the source of these organisms was thought to be the surface of the cane. Hence, the first part of the experiment was to disinfect the cut ends. It was soon found that a dilute disinfecting solution was better than the treatment of the cut ends.

The results so far obtained show two methods of value:

(1) Lowest joint is cut away under water each day and the water in which the cane is standing is kept clean and fresh.

(2) Lowest joint is cut away under water, and the cane is transferred to a dilute solution of sulphurous acid, 1 part SO_2 gas in 2,000 parts tap water. The

Fig. 2. Stalk being placed in the sulphurous acid solution. Note the partly emerged tassel.

solution is changed whenever turbidity is noted. As a general rule we have no turbidity if the sulphurous acid solution is properly made. When it is necessary to change a turbid solution one may as well change the tassel also, for if it has once commenced to wilt it will not recover.

The following notes by Mr. Das give a few typical tests made and show the progress of the work to the present time.

In this work Mr. Das has shown resourcefulness and initiative and deserves great credit for the results obtained:

The following gives steps taken in developing the sulphurous acid solution method of keeping cane tassels:

The tassels are cut with 2 to 4 feet of cane stalk (joints) on them.

(1) The cut cane is put in tap water, changed every day.

(2) The cut ends are immersed for about one minute in acid and then put in water.

(3) The cut ends are immersed for one minute in alkali and then put in water.

(4) The cut cane is put in a standard nutrient solution.

The canes all began to wilt and die in two or three days and slime was detected. The next step was to have the slime examined by the Pathology department.* It was found to contain bacteria, protozoa and fungi. Henceforth, our efforts were directed to controlling the growth of slime or keeping it in check. The first disinfectant used was mercuric chloride (1 in 20,000). This gave a better result and confirmed our belief that slime was an important factor. In another test the cut cane was put in tap water which was changed every day, and each day the bottom joint was cut off, thus exposing a new surface to the clean water. The sticks did very well and we were able to keep them fresh two or three weeks and even longer. We later found that it was necessary to always cut at least one joint every day. It is necessary to cut off a node each time.

Mercuric chloride (1 in 20,000) did not, however, come up to our full expectations. We thought it was too strong and we thereafter used more dilute solutions down to 1 in 100,000. There was no growth of slime, but the cane sticks never did very well, or as well as the sticks in water which had one joint cut every day. $HgCl_2$ together with sugar solutions of various strengths and standard nutrient solution was later on tried, but no encouraging result was obtained. Some canes were first sterilized for different periods in $HgCl_2$ and then put in water changed every day, but with the same result.

We then tried cane sugar solution of various strengths, but in all cases the canes began to die in two or three days.

We also used lime water, soil solution and many inorganic salts such as ammonium chloride, magnesium chloride and lead chloride. We tried camphor, ether, chloroform and alcohol in water, but with no success. We then concentrated our attention to finding some mild disinfectant that would not have the killing power of mercuric chloride, but which would be as effective in keeping off the growth of organisms in water. We have tried the following:

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* The Pathology department has been of great help in this work. At the present time Mr. Barnum is devoting all of his time to a study of pollens and related problems.

Fig. 3. This stalk has been in the sulphurous acid solution one week. Flowers are still opening and are giving good pollen.

Fig. 4. Method used in obtaining crosses by means of the sulphurous acid method. Tassels of the varieties to be crossed are placed in the solution and kept in a sunlit pollen-proof room. In the early morning the tassels are shaken to scatter the pollen. When mature, all tassels are planted.

(1) Potassium permanganate—1 gm. in 1,000 cc. of water.

(2) Aspirin—20 grains in 1,000 cc. of water.

The cane did fairly well for about six days, but soon after the leaves began to die.

(3) Formalin (40 per cent commercial product) 5 cc. in 1,000 cc.

It was too strong; leaves appeared scorched.

(4) Boric acid—.1 gm. in 1,000 cc. of water,

.5 gm. in 1,000 cc. of water.

(5) Hydrogen peroxide (commercial product)

250 cc. in 1,000 cc.

143 cc. in 1,000 cc.

With (3), (4) and (5) the leaves became dry and brittle in one day.

(6) Sodium sulphite—2 gms. in 1,000 cc.

(7) Sulphurous acid (H_2SO_3) various strengths.

Sulphurous acid has proved successful, though we cannot say it is perfect as yet. We shall give our trials with sulphurous acid in some detail.

The first experiment with sulphurous acid was started on September 15. The strength used was 1 cc. of the commercial product (original analysis 8.3 per cent SO_2) to 100 cc. of water. In a day or two it was noticed that the leaves not only kept fresh but there was a marked growth of stalk. This growth continued as long as the stick was alive, though during the later stages the rate of growth fell off.

The first stick was alive about a week when, through some accidental circumstances, the experiment was lost. However, it gave us very good indications and we tried another batch of new canes. All these stood the test remarkably well, and in all cases the cane was alive for more than two weeks. In one case the stick was alive for about one month and the growth during the period was nearly one and one-half feet. During all these days the solution was not changed, nor was any part of the stalk cut off. As the solution was taken up by the stalks new solution was added to make up. Our attempt was now to find the optimum strength of the solution in which the cane will do its best. We now tried the same acid diluted as follows:

.5 cc. to 100
1 cc. to 100
1.5 cc. to 100
2 cc. to 100

It was found that while the cane did pretty well in all these solutions, the solutions of higher strengths (1.5 cc. to 2 cc. to 100) had some strong effect on the leaves. The solution .5 cc. to 100 turned turbid at the end of 8 days and the stick died soon after. So it was concluded that 1 cc. of the acid to 100 water was the best strength. We then began to apply our experimental results on a big scale and under regular field conditions. Here we were faced with one minor difficulty. The original stalk of H_2SO_3 being finished, we had to use acid freshly prepared in our laboratories. We found that 1 to 100 of an 8 per cent H_2SO_3 was too strong for the leaves. We then worked down to 1 to 100 of a 5 per cent acid freshly prepared. This time we got the same results as in our previous experiments. The sulphurous acid first used had probably weakened on standing. This probably explained the incongruity in the experimental results. How-

ever, we have now given this 1 to 100 of 5 per cent acid a fair trial and are getting fine results. We have been able to keep tassels alive in this solution for two weeks and even more. We have obtained good pollen all the time and some actual germination of seedlings.

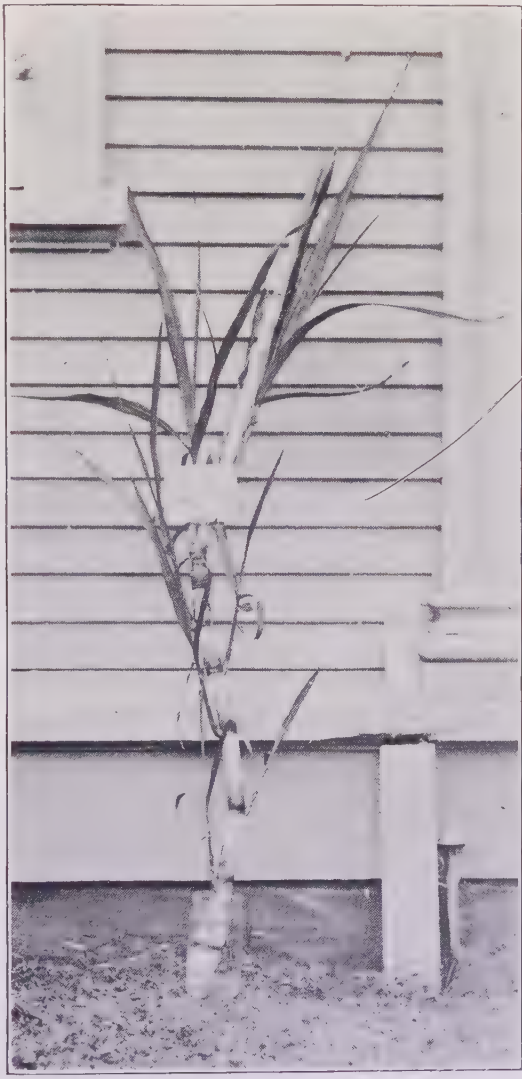

Fig. 5. This stalk has been in the sulphurous acid solution for over a month. The tassel matured, was planted and germinations obtained. Note the sprouted eyes. All of this growth has occurred since placing the stalk in the solution. Selfs may also be obtained in this way.

We still feel that some more improvements could be made, even on this, and we have been trying it in many other ways. We have also been trying other organic acids and salts and some other disinfectants.* But one point especially associated

* Since writing the above we have started a test with Dakin's Solution with very encouraging indications.

with this H_2SO_3 is its power of stimulating growth. In this connection, we may mention one interesting experiment we made with ice. The cane put in ice looked fresh, but as soon as ice was withdrawn it died. During these three or four days there was no growth at all.

The Propagation of Seedling Canes*

Notes on Collection of Tassels and Nursery Technic

By W. P. Alexander

The Committee on Varieties feels that every effort should be made to improve the technic employed in the propagation of seedling canes. With this aim in view they believe that as a starting point all information which is available should be recorded sooner or later, and that such an exchange of data will increase progress.

The subject is demanding attention under the following heads:

(1) Botanical Studies of Cane Flowers.
(2) Methods of Securing Natural Crosses in the Field.
(3) Methods of Securing Artificial Crosses in Field.
(4) Methods of Caging Flowers Either for Selfs or Crosses.
(5) Nursery Technic.
(6) Selection of New Seedlings:
  a. Preliminary eliminations.
  b. Choice and development of new commercial varieties.

Since only a long treatise could completely cover the project, this report will attempt only to treat of two of the above points, Nos. 2 and 4, namely, the securing of natural field crosses without artificial means, and the nursery technic involved in growing the seed. It is this work that can be undertaken successfully by the individual plantation with little financial outlay and the least amount of experience. The results may not be secured along strictly scientific lines of a plant breeder. Nevertheless in spite of this haphazard manner of securing crosses, the results justify such "commercial" raising of new varieties. H 109 in Hawaii, D 625 in British Guiana, probably E. K. 28 in Java, and others, are the products of this process.

The more delicate work in obtaining artificial crosses in cages or otherwise should be encouraged by all and receive the consideration of specialists at the Experiment Station until a more complete system than we have at present has been perfected.

The mode of procedure in collecting tassels and the planting and care of seedlings in the nursery will vary according to different conditions, and it is not

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* Presented at the Third Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

the purpose of this report to lay down rules to be followed. "Experience is the best teacher." The findings and the practices adopted by some of the cane breeders working in Hawaii have been brought together and are presented in detail. There is some repetition of ideas within the different quotations and the methods have been gone into rather minutely, for the report is written mainly for the use of those who are intensively engaged in the project.

Some interesting developments of the 1924 season are described and may be briefly mentioned:

(1) Mud press (decomposed) as a media on which to germinate fuzz was used by W. P. Naquin at Honokaa. (See page 102.)

(2) An incubator for germinating fuzz during unfavorable weather was operated by W. C. Jennings at Hawi. (See page 99.)

(3) Green algae and fungi in the original seed beds were controlled by Bordeaux dust and by using a surface soil having little or no organic matter. (See pages 102 and 108.)

The writer is indebted to Messrs. W. C. Jennings, Y. Kutsunai, W. P. Naquin and C. F. Poole for their cooperation in the preparation of this report. Their help made possible a fairly comprehensive summary of the *present* status of our information concerning the collection of tassels in the open field and the nursery technic.

Collection of Tassels

To provide the proper seed material, the collection of tassels when secured in the open field requires careful planning and strict attention to certain fundamentals.

First, the cane breeder must obtain his tassels with a definite purpose in mind as to the new variety wanted. It is profitless to indiscriminately secure tassels without a reason. For example, at Ewa, we keep two points in mind, namely, resistance to eye spot leaf disease and an early maturing of the cane. Mr. Jennings, in Kohala, says: "In our seedling work in Kohala our first aim is to breed canes that will be improvements on D 1135 and Tip canes, the present standard varieties of the district, and we consider that the first logical step in this direction would be the crossing of these varieties. In these crosses we expect to find combinations of the best characters of both varieties, and with these combinations of characters we would expect to develop mostly mauka varieties. In our work on the development of lower-land canes we have attempted to cross D 1135 and the Tips with Badila, Striped Mexican and H 109." The choice of the right parents is most important and the writer can frankly state that it is his experience and that of others that the promiscuous planting of seed from many inferior non-commercial canes has caused a loss of time and energy which could have been devoted to more profitable crosses.

Certain botanical knowledge should be secured about the inflorescences of each variety of cane. It is a great aid to the efficient collection of the tassels. Armed with such information no time will be wasted securing tassels from varieties in which the female part of flower (ovule) is not normally developed. One

should know also what varieties produce little or no pollen. More data is needed on this subject in the Hawaiian Islands. In India and Java and Cuba* a great deal of work has been done so that cane breeding is progressing without "waste motion." Here are some "observations" that have been made in Hawaii: H 109, Lahaina and Tip canes can be counted on as splendid female parents. Their male function is often in doubt. D 1135 is able to serve well as either parent. H 146 has most virile pollen. Badila has normal reproducing organs when it does tassel, which is seldom. Yellow Caledonia is sterile (a mule). Fertile seed is more easily obtained in any case when different varieties are in proximity, i. e., when crosses are actually secured.

A preliminary survey of the possible parents at hand and the location of their relative position in the field so as to serve as crosses is the common plan of procedure by Jennings, Kutsunai, Poole and the writer.

The tassels selected for the seed material will be at the leeward side of the hoped-for pollinating variety. Under ordinary conditions the two varieties desired to be crossed seldom seem to have mature flowers at the same time in the same locality. As pointed out by the writer in a report on tasseling, a year ago, there is a large field for investigation as to the phenomena of tasseling. If as claimed in India† we could control the time of tasseling, crossing of different varieties would be more certain.

Inspection is made as often as possible to watch the progress of tasseling and be ready to cut the tassel when ripe.

Theoretically, the collection of the fertile seed should not be difficult, in practice, the reverse holds true. Only through tireless energy and by many careful observations will one succeed in obtaining seed that will germinate well. Then in spite of the best laid plans, the weather conditions may be unfavorable. It appears that during the period of flowering prime conditions are, dry weather and little wind. Normal transferrence of the pollen to stigma will not take place if there is high wind which dries up the stigmas or blows away pollen grain before they mature and wet weather which washes off the pollen grains, or they may burst prematurely after they absorb moisture. Also after pollination has taken place, the plant seems to require good growing conditions so that the seed may reach full development. So it is that Kutsunai looks for "a vigorous cane which is always chosen as the one from which to take tassels. Tassels from a long crop are preferred to those from a short crop, also a field with heavy tasseling is thought to give better germination than a sparsely tasseled field. As far as possible, the tassels in more or less protected places are cut.

"Tassels on weak stalks are smaller than on well developed sticks. Many tassels emerge merely to dry, showing that the stalks below have no reserve energy to ripen the seeds. This condition is very closely correlated with young

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*Venkatraman, T. S., Agricultural Journal of India, Vol. XVII, Part 2.

Handbook Sugar Cane Culture in Java—Chap. VII.

Calvino, E. M., Studies in Anatomy and Physiology of Sugar Cane in Cuba.

† Venkatraman, T. S., Agricultural Journal of India, Special Indian Science Congress Number, 1917.

cane, weak growth, and late tasseling. Sometimes heavy wind brings on premature drying of the tassels. Cane along ditches and leeward edges is usually well developed and are satisfactory for the source of tassels."

The uncertainty of weather conditions is a factor everywhere, to quote Jennings, "My working plan each day during the early part of the season is based upon the assumption that each particular day may be the last opportunity for collecting tassels before heavy wind or rain damages the tassel crop for the season." The tassel may take two weeks to entirely emerge and the flowers on the tassel bloom gradually from the top down, and it may take another two weeks for the tassel to complete its entire florescence. In order to get some seed at least before the weather turns unfavorable at Ewa picking tassels is started when the tops only are mature. However, collection of tassels in earnest proceeds when the whole tassel has flowered. At this time the fuzz will shake off easily and the stem of the tassel has started to wither and turns yellow. In Java the flowers are cut when the last small leaf, the little flag, begins to dry. A much larger collection of tassels must be made from each location than may actually be wanted for planting, and these will be stored until germination tests have proven their value. If one does not have a surplus on hand he is likely to find himself without enough seed if the season prevents further tassel collection or if there are adverse conditions resulting in mortality in the nursery.

Experience of all those doing seedling work has shown that it is the early tassels, even though only the top is ripe, that usually give the best results, although Jennings reports, "occasionally, under Kohala weather conditions, earlier maturing tassels may fail to set seed, while late tassels may give good results."

If there was a sure test of the fertility of the seed that could be made in the field or before planting, time and labor might be saved. Jennings' experience of having one lot of fuzz in six providing fertile seed, is a good ratio even under better weather conditions. The only practical means of testing seems to be to plant a representative sample, and the resultant germination will decide whether the balance of the seed is to be used or discarded. Kutsunai describes some of his methods for the examination of seed in the fuzz and also viable pollen:

Usually a few early tassels are cut and examined for seeds. The fuzz is scraped, rolled forcibly between the hands, and all solid particles are examined with a magnifier of 10 to 20 diameters. Another and a better method is to grind the fuzz in a meat chopper with the knife set about ⅛ of an inch open, the ground fuzz is stirred in water, and all the particles that have sunk down to the bottom are examined with a lense of 10 to 20 power. The seeds are often broken but can be easily recognized. These two methods are very quick but more or less crude.

Iodine stains pollen which appears to be good and normal. But the iodine does not differentiate live pollen from dead pollen. The methods look good for obtaining percentage of viable pollen in the flowers. For want of a good method for germinating pollen, the results of iodine tests could not be checked with viability of pollen.

Bare seeds placed on blotting paper the edges of which have been folded into a well of water germinate well. When the fuzz is tested, the seed bed of soil is thought to be quite satisfactory.

Usually the whole tassel is cut without the stem. Sometimes, however, the collector may only take the top portion. Again, one may prefer to leave all the stem and even several joints of the stalk.

Treatment of Tassels

The tassels are bagged in the field and labeled for identification of parents, etc. Kutsunai and Jennings have used muslin bags; Alexander and Poole find paper bags are cheaper and answer the purpose. The treatment before planting the fuzz has not been standardized, and perhaps more care in drying tassels should be exercised as the excellent results secured by Jennings would indicate. His methods are described in full:

> The greatest difficulty in the care of tassels after cutting is the prevention of mildewing before planting. If the fuzz is not well cared for the mildewing will become evident immediately after planting, even though not noticeable in the muslin bags. The bulk of the tassels are cut when only the tips or upper halves have ripened, which makes curing difficult, especially in cloudy, rainy weather.
>
> The tassels when brought in from the field are hung up in bundles of ten and left to dry two days or more before placing in muslin bags. Not more than ten tassels are put in a bag and the bags are always hung up, never laid on a floor or piled up. Every clear day the bagged tassels are taken out and hung up exposed to the sun. If there is a shortage of bags the fuzz is stripped after a week or ten days. In bagging, the fuzz of not more than fifty tassels can be placed in one bag. The bag is tied near the top to make as much space as possible and the fuzz is shaken up every day to prevent packing and to allow some air circulation.
>
> At the beginning of the season the muslin bags used in curing and storing tassels are all sterilized by boiling, and if at any time during the season the slightest musty odor is detected, the bags are sterilized before using again.
>
> During the period of protracted rainy and cloudy weather last December kerosene heaters were kept going continuously in our main store-room of bagged tassels. I believe that the drying effect of these heaters kept some of our best lots of tassels from spoiling during this weather.

During very dry weather fuzz may be planted immediately if collected after all dew has been evaporated. However, as Kutsunai points out, "the tiny seedlings growing out of the seeds sticking firmly to the branches of the tassels are difficult to transplant without much disturbing." When there is a short drying period the fuzz is more easily removed by shaking into a bag or by rolling two or three stems of the tassels between the hands. If it is necessary to pull the fuzz off it usually shows that at least part of the flowers are immature, and seed has not yet been formed.

The cane seed does not keep well. Seed which is in storage for over one month will not germinate well. Seed planted within 10 days of picking will provide the best germinations. Older seed also seems to lack vitality. Just what might be done to prevent this quick deterioration has not been discovered. Nature has not provided the seed with the protective protein covering, etc., which robust seeds have. It is believed that oxidation takes place rapidly and the life germ is soon extinguished. If the keeping qualities of the seed were only good it would be possible to store seed until better growing conditions were provided than are found in the winter season.

Given warm weather, with little overcast sky, and no heavy rains with accompanying moisture-laden atmosphere, the nursery work of germinating and growing the seedlings would be easy. It is seldom that these conditions exist in the months of December and January, and it is unfortunate that seeds will not remain virile but must be planted at that time.

Nursery Technic

The equipments used in the open nursery by those raising 5,000 seedlings or over varied and can best be told by each cane breeder who had to meet different climatic conditions.

Mr. Jennings, working in Kohala from December 4, 1923, to January 29, 1924, when it was necessary to germinate the bulk of the seedlings for the 1924 season, had a nursery at Hawi at an elevation of 625 feet. The mean temperature ranged from 66° to 70° F., and there were heavy winds to complicate all operations. He writes as follows:

I have tried out several different types of cold frames and covers for sun and wind protection at Hawi this year. Three types of glass-covered (one with painted glass) and two of muslin-covered incubators which were electrically heated were tried. These incubators were divided into sections containing about 40 cubic feet of air space and each section was heated by four 100-watt, 110-volt, Mazda lamps. It was possible to keep the temperature up to 70° F. during the coolest nights in the glass-covered incubators with these lamps. The clear glass-covered incubators heated this way gave very good results, while with the painted glass- and muslin-covered type no better results were secured than with the ordinary muslin-covered cold frames.

Fig. 1

Fig. 1 shows the glass-covered electrically heated incubator.

Fig. 2 shows the most economical and successful types of covering for germination flats that we have tried yet at Hawi. This bench was built facing the south in

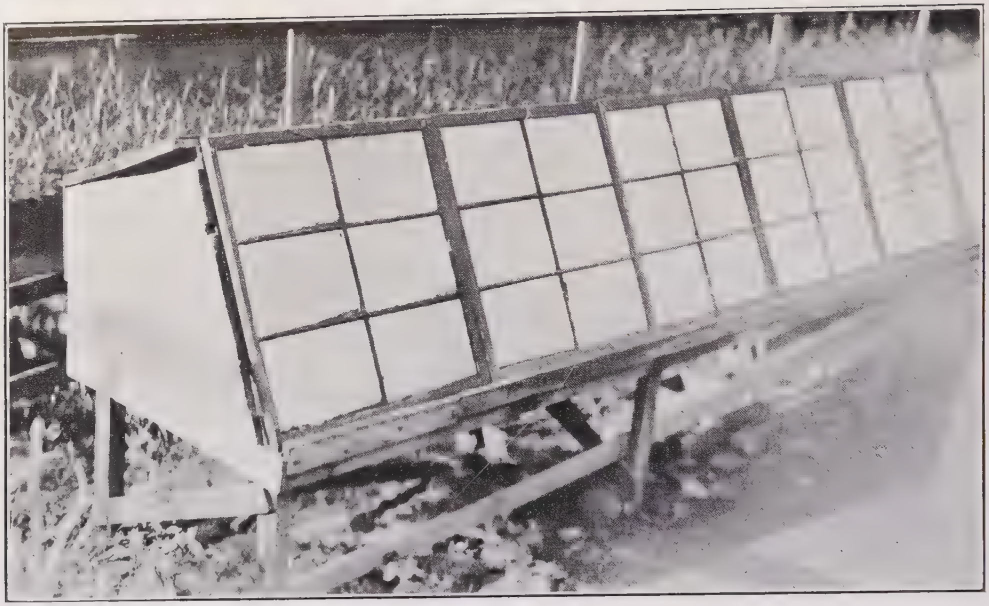

Fig. 2

order to get all the direct sunlight possible into the fuzz flats. The front side is covered with ordinary window sashes, and top and back sides are covered with roofing paper for protection from the wind and rain. With this arrangement the temperature under the glass goes up to over 110° F. on clear days. Several tests comparing germination in the glass-covered frames with that in the muslin-covered frames were conducted. The fuzz planted under glass gave from three to five times heavier germination and in less than half the time required for fuzz from the same lots planted under muslin.

The most satisfactory type of muslin-covered frame for Kohala conditions is shown in Fig. 3. This frame also faces the south. The bench is four feet wide with an eighteen-inch wall at the back. The back wall is for wind protection and the bench is four feet wide, though too narrow to work conveniently, for the reason that with this high backwall a narrower bench would be too dark, especially when the muslin cover is down.

The convenience in weeding and caring for the potted seedlings when grown on the benches will result in a labor saving that will soon pay for the extra cost.

Poole at Eleele and Makaweli, Kauai, and Naquin at Honokaa, were able to accomplish their nursery work without any protection against rain or sun. A windbreak, however, was constructed at Eleele.

Kutsunai, stationed at Makiki, Honolulu, and the writer, at Ewa, used cold frames with cloth covers. The former had some glass covers during the heavy rain storms.

These cold frames, as shown in Figs. 3 and 4, will answer all practical purposes. The writer gave up portable frames, or those on hinges, in place of a roller arrangement which makes an ideal covering. The tent effect sheds water readily and it can be easily raised up on legs as the seedlings grow. During a windstorm, there are no covers to blow loose.

The writer has used many different styles of frames and covers to provide protection from the sun and rain. Under different conditions on Hawaii

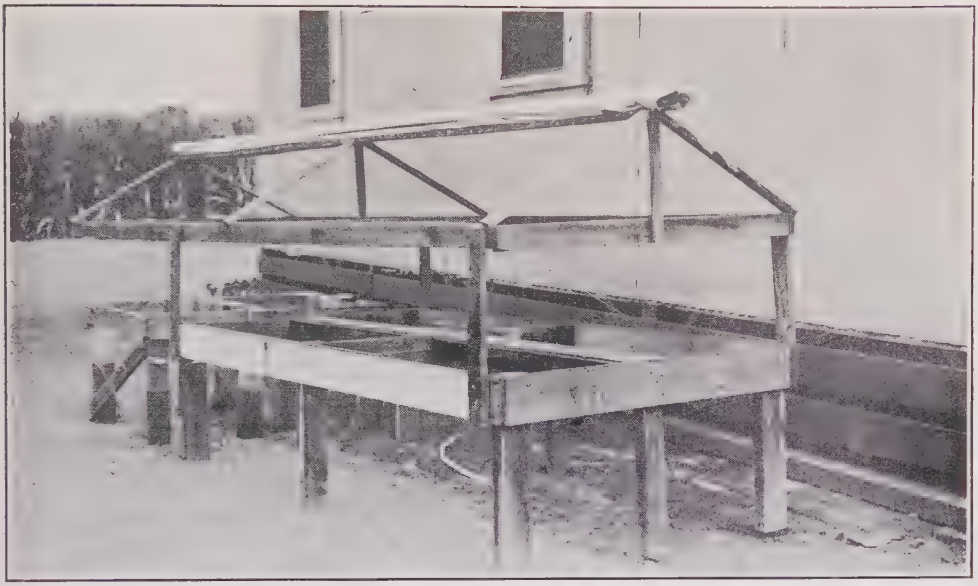

Fig. 3

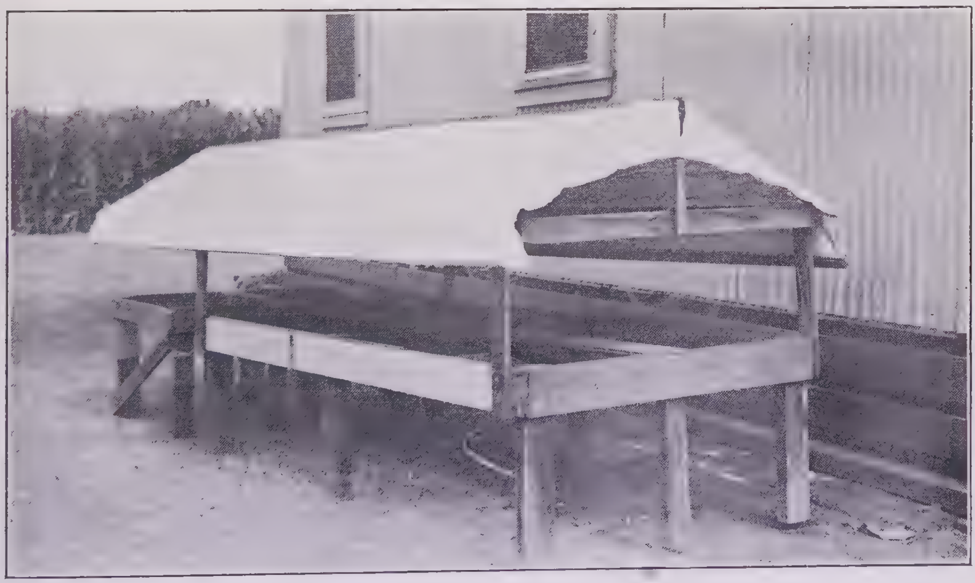

Fig. 4

he has obtained satisfaction under all conditions from the ones which have painted glass covers, placed about 2 feet above the flats, and made from old windows. They afford good ventilation, and one may easily regulate the amount of direct sunlight the cane is to receive. Such equipment is too expensive when a plantation is propagating seedlings on more than a small scale.

The flats used by Kutsunai at the Experiment Station are 12¾″ wide, 24¼″ long and 2¾″ deep (inside dimensions). The writer has used different sized flats for the plantings, and has finally standardized on one which is 24″x24″x6″. It has the disadvantage of being too heavy for one man to handle by himself when it is filled with soil. Three things are in its favor: (1) It does not dry out as quickly as a narrow, shallow flat does. (2) The depth of soil allows the plants to remain in the flats longer, two months if necessary, without the roots being cramped. (3) Later the boxes are a convenient size to hold 25 pots. It is absolutely essential that enough holes or cracks be made in the bottom of the flats to provide perfect drainage. Nothing can be more harmful than a waterlogged flat.

Jennings finds that "any size or style of flat that has sufficient openings in the bottom for good drainage and that will hold soil to a depth of not less than three inches is O. K." Old flats or flats that have been used recently must be sterilized by being placed in the boiler of the soil sterilizer while soil is being sterilized. He finds much more difficulty in caring for fuzz in old or used flats that have not been sterilized, as the fungus and algae spread very rapidly from the sides of the flats onto the fuzz.

Jennings, Poole and the writer prefer to have flats placed on benches.

The question of what soil to use in the first plantings has been decided by each worker for himself.

Kutsunai, at Makiki, has usually used a mixture of two parts of rich and mellow garden soil and one part coral sand. Poole had success at Eleele with the same soil.

The writer's experience on Hawaii and at Ewa is in agreement with Jennings, who states: "I have had best success by selecting soil that was as free as possible of organic matter. Addition of coral sand to improve the texture of our rather heavy soil and of stable manure or compost for fertility have not been successful. The addition of sand results in a soil mixture of lesser fertility, while stable manure and compost make the control of fungus and algae more difficult."

The richer and more friable the soil is the better are the results obtained from the original plantings. A certain amount of screening of soil is necessary to obtain an even surface.

A most important discovery has been made at Honokaa, in that *decomposed* mud press is an ideal material upon which to lay the cane fuzz. Its fertility, drainage properties, and freedom from algae or green fungus, according to Mr. W. P. Naquin, Manager of Honokaa Sugar Co., should make it acceptable to all cane seedling nurseries. He writes:

During the past year we have made radical changes in the technic of germinating and handling seedlings. On account of high elevation and cold weather we have had some trouble with a green fungus which destroys most of our seedlings before they can be transplanted to the fields. As the sun is one of the best antidotes for this fungus I decided this year to eliminate all artificial protection of young seedlings and let Nature take its regular course. We have been so successful with this method that we feel it is worthy of a trial in other places. When this natural process is followed, however, we find that water becomes a limiting factor, and unless constant

irrigation is resorted to the cane wilts from the excessive sun. Then, under intensive irrigation the soil becomes soggy and soon we have another condition which is about as bad as the green fungus. After many experiments with different soils we found that decomposed mud press, which contains a considerable amount of wax and lime, is a most excellent soil media in which to grow seedlings.

Owing to the texture of this mud press continuous irrigation does not produce any injurious effects, and it is possible to grow seedlings in the open.

We have tried different proportions of mud press to soil, but in no instance was a combination superior to the straight decomposed mud press.

We have raised some 10,000 seedlings this year at Kukuihaele, with very little loss from damping-off or green fungus. The mud press, aside from being an excellent material for this work, is easy to obtain on all plantations. It should be allowed to rot at least 6 months before it is used, keeping the pile sufficiently damp to allow all fermentation to take place before it is used.

Theoretically, sterilization of the soil is beneficial in that fungus is eliminated. However in actual practice the soil soon becomes reinoculated by the water and exposure to the air. Steaming of the soil, therefore, is done to eliminate grass and weed seeds which will grow during the first weeks, and may be confused with tiny canes. This is especially true of manienie or Bermuda grass. The saving in labor due to freedom from weeds pays for the extra handling of the soil in the sterilizer.

If exhaust steam is available from some engine the sterilization is very simple. A perforated pipe placed in the bottom of an old tank or box upon which the soil in bags is laid and then covered, serves very well. Where steam has to be generated the writer used several schemes, the best of which was a large wash boiler over an open fire upon which several layers of trays filled with soil were placed. The bottom of the trays consisted of a small mesh screen. Baking of the soil is often practiced in other countries, but has a tendency to rob the soil of organic matter.

Planting the Fuzz and Care of Young Seedlings

Nursery work, the growing of any young plants, demands attention to details brought about by special local conditions. Success is the result of very close *personal* supervision of the soil, moisture and heat environment given the germinating seed bed. With proper care fungus troubles are less apt to occur.

Instead of trying to combine the reports received from Jennings, Kutsunai and Poole with the writer's experience, each of the four statements is given in full. The principles involved are:

(1) A fertile soil that will not compact, having good drainage and free from agencies that increase fungus growth.

(2) Optimum moisture conditions determined by careful observations correlated with the conditions of temperature and sunlight.

(3) Taking full advantage of sunlight not only to produce growth but to kill fungus.

Hawi and Kohala, W. C. Jennings:

After much experimenting during the last two seasons I have arrived at the following method of handling fuzz flats.

The fuzz is spread very thickly on the germination flats and pressed down with large quantities of water into a firm, rather tough layer ⅛ to ¼ of an inch thick. The flats are then placed under glass in the frames shown in Fig. 2 and exposed to direct sunlight. The fuzz is watered with a fine spray nozzle two or three times an hour while the sun is shining. On cloudy days it may be necessary to irrigate only two or three times a day. In sunshiny weather I expect the first signs of germination to appear in four or five days. If germination does begin on the fourth or fifth day, by the twelfth day I begin to increase the period between irrigations. In two or three days the number of irrigations are decreased from many light irrigations daily to one or two rather heavy irrigations a day.

The temperature under the glass will go up to over 110° F. with a few hours of sunlight. The fuzz exposed to direct sunlight and in this temperature dries quickly and requires frequent watering. From 9:00 A. M. to 3:00 P. M. on clear days the fuzz flats require almost constant attention, as only enough water to wet down the fuzz is applied at one time. The fuzz is kept constantly moist, yet, so little water is applied each time that the soil in the bottom of the flats will be found almost dry two weeks after planting.

If germination has started on the fourth or fifth day after planting and the young seedlings have not been irrigated too heavily root development will have been well started by the twelfth to fifteenth day. At this stage the periods between irrigations, are gradually lengthened, giving the roots time to get through the fuzz and into the soil before drying out the fuzz too completely. I believe, as a result of having examined the roots of several hundreds of young seedlings, that two or three days is sufficient time for the development of ¼ to ½ inch of root in the seedlings when subjected to this treatment.

The heavy coating of fuzz acts as a mulch and so retains the moisture in the soil beneath that one irrigation a day, except on the very hottest days, is sufficient when once the roots of the seedlings have reached the soil. After the treatment outlined above it is assumed that the roots have reached the soil by the fifteenth to eighteenth days, and irrigation is applied only when the upper part of the fuzz layer has completely dried out. Sufficient water is applied at this stage to soak the soils and then in no case is the flat irrigated again until the fuzz is dried out again. This method of treatment I consider as the most important development in the work at Hawi this year. By this method we have entirely eliminated all trouble with algae, fungus, etc., as the fuzz becomes so dry on top that everything of this order is burned out by the direct sunlight.

There may be some sacrifice of late germinating seed by this method, but vigor of the seedlings already attained will more than compensate for this loss.

In cloudy wather no irrigation is applied until the fuzz dries out even though it be for several days, for as long as there is any moisture at all in the fuzz it can be safely assumed that the soil below has more than sufficient moisture for seedling growth.

Makiki, H. S. P. A., Y. Kutsunai:

Depth of Layer: The fuzz is planted on the soil surface, not in the soil. The thickness of the fuzz planted depends on the germinating capacity of the fuzz. The ordinary run of the fuzz is planted about ¾ of an inch thick before wetting. If the fuzz is very important, it is planted very thin.

Care of Flats—Good Growing Weather—During the First Week: During the first week the fuzz boxes are watered twice a day. The boxes are not covered unless the weather happens to be windy or excessively drying. In most cases, the fuzz is found difficult to keep wet unless covered.

During the Next Two Weeks: At the end of a week after planting the fuzz, tiny seedlings are coming up. They seem to take strong sunlight to good advantage. Sometimes ammonium sulphate in solution is applied at the rate of 3½ grams to a flat.

After Third Week: During this week, the young seedlings become about three-quarter to one inch in height, and they have about three leaves. They are then ready to transplant into another box or pots. The care given to them is essentially the same as the previous week.

Influence of Adverse Growing Conditions: During cloudy weather the covers on the cold frames are kept away, even though the fuzz in the flats is drying a little.

Excessive Moisture Due to Rainfall: Irrigation is cut down.

Cold Nights: The cold frames are covered every night, not for retaining heat, but for protection against heavy rain. No heating is practiced unless the fuzz is a very important one.

Eleele and Makaweli, Kauai. C. F. Poole:

Fuzz was placed in the flats so as to be level with the top of the flat, and shipping tags bearing descriptions of the cane to the windward, the parent tassel, date cut, date planted, and, later on, the date when first shoots appeared, were tacked on the front.

Watering of the flats after planting of the fuzz varied with the germination of the seedlings. No germination was received till the day after Christmas, when warm Kona weather prevailed, and that in flats of D 1135 planted December 10th. A month later some germinations in seedlings of Lahaina occurred in from 7 to 10 days, first appearance, and subsequent germinations continued appearing for about three weeks, with the heaviest occurrence about eleven days afterward. A fine spray nozzle, originally purchased for a bagasse spraying experiment in the mill, was used for irrigations about four times daily until all shoots appeared to have come. After that the flats were watered twice daily until there were about six leaves per shoot. The germinations were much slower than are usually obtained in other localities, seemingly due to the low temperatures on Kauai during December and January nights. The minimum temperature was seldom over 63 degrees until the beginning of April.

There was an unaccountable difference between growing conditions found at Makaweli and at Eleele. Germinations seemed to come sooner at Makaweli, no doubt due to the higher temperature; but after appearance the Makaweli seedlings grew very slowly, while the Eleele seedlings grew straight ahead.

Ewa, W. P. Alexander:

Planting the Fuzz: I do not like to spread the fuzz on the soil too thickly. When the layer is over ⅛ inch (wet) the moisture conditions are more difficult to regulate, as the fuzz dries out quickly and the tender seedlings just starting fail to get their roots into the soil before they dry up. The fuzz needs to be gently pressed on top of the damp soil, but with few exceptions any attempt to cover the fuzz with a thin layer of soil has resulted unfavorably.

I have tried treating the soil before planting with a very weak solution of sulphate of ammonia, but would not recommend it as a general practice. It seemed to stimulate the growth of moss more than it benefited the initial start of the cane.

Care of Seedlings in Flats: Given warm weather, mean temperature of 75° F., night not less than 65° F., the canes will germinate well and without much fussing over them. I find a complete muslin cover for the first 4 to 5 days after planting allows for an easier control of uniform moisture conditions. For the next 10 days, when germination will be most rapid, exposure to direct sunlight must be reduced from 10 a. m. to 2:30 p. m. under Ewa conditions. If weather is cloudy I do not cover at all, as this is the time fungus gets a start and all the light and ventilation possible are necessary. After the third week I try to give as much sunlight as possible without causing the surface moisture to dry out so that the plants wither. No set rule can be given for irrigation. The water should be applied as a fine spray until the plants are large. After germinations have stopped it is better to irrigate only once a day and to cover the flats during the middle of the day than to get the soil so dry that an irrigation is needed then. Each water drop on the leaves at noontime will act as a magnifying lens. The minute burn thus made on the leaf forms a sore spot where fungus will easily attack it. Saline irrigation is harmful when the

salt content is over 50 grains per U. S. gallon. The tender shoots are burned and salt accumulates in the soil to form a toxic condition. Water with 26 grains has been used when no other was available and yet there appeared to be some stunting of growth.

Provided the weather is warm and dry the initial nursery work as described above will be found to present few problems. It is, however, adverse conditions such as:

(1) Cloudy weather without wind causing the rapid increase of fungus, both damping-off and leaf troubles;

(2) Excessive moisture from rains not only benefiting fungus, but also rotting the seed;

(3) Cold nights below 65° F.,

which seem to prevent germination and stunt all growth which may have previously started. Such unfavorable factors keep one's wits alive to coax the germinations and eliminate disease. The above conditions are the rule rather than the exception for certain periods every winter season. The best thing is to get started early enough before the trouble begins. One can nurse a large proportion of cane several weeks old through a bad spell. To overcome the poor environment is another thing working in the open. I have had only fair success, and sometimes complete failure when contending with lack of sunshine, cold days, and nights and excessive moisture in the air. The results of the 1923-1924 season are still fresh in my mind. What appeared to be an unusually good start was turned into a hard fight to pull through one-third of those germinated before the end of December, and practically no germinations were secured from 150 flats planted afterwards.

When growing conditions are worst, the moisture must be kept at a minimum. Some method of sub-irrigation would be ideal, so that water would not be applied on the surface. Use must be made of every bit of sunlight. Every effort must be made not to interfere with a good air current through the flats. In spite of these precautions the algae will grow and fungus will get a hold. The little plants seem to have no resistance to disease when their vitality is at a low ebb.

My experience with any form of incubation has shown that it must be done for a short period, say not over five days after planting and then the change to nursery conditions and ordinary temperatures and light must be gradual. Very often the plants that are thus forced will not grow to be strong healthy seedlings.

Differences in Germination

There is a great difference in the percentage of germination one secures. Sometimes the flats will be literally green with the tiny shoots, and again one is fortunate to get a dozen seedlings to a flat. There also appears to be much variation in the vigor of the little canes. Very often the most prolific seeds will have weak-growing canes. This is also true in India. Varieties that are not commercial canes will give seedlings that lack vigor from the start.

Kutsunai has made the following notes on germination of the fuzz:

> In glass houses, the flats containing approximately the same quantity of one lot of cane fuzz germinate differently according to the place given them in the glass houses. The boxes near the east, the south, and the west side germinate much better than those in the central position.
>
> The age of the tassels, or the interval between the cutting and the planting of the tassels, affects germination very much. The tassels heat up when packed closely, before drying. The fuzz from such tassels does not germinate well. Early cut tassels germinate better than late cut tassels. Ripe tassels germinate better than overripe tassels.

Transplanting Seedlings and Care of Potted Seedlings

The methods adopted in transplanting are more uniform, although here too the personal element influences the mode of procedure.

Ewa, W. P. Alexander:

For several seasons on Hawaii, after trying out transplanting the cane when three or four weeks old into a second flat, the writer has had for three years at Ewa, good success with direct potting of the seedlings when about six leaves had appeared, thus eliminating one step and saving much labor. The mortality is less when there is only one transplanting. Even so, one must expect some dying out as a result of root disturbance, if the seedlings have germinated closely together.

The kind of soil used in the pots has a decided influence on the growth the plants make. A soil mixture with a leaf mould compost will have the splendid moisture holding capacity and the new roots spread rapidly in the good tilth.

During the time it takes the roots to get adjusted the plants must be kept in the shade.

A mulch of some kind over the surface of the soil in the pots prevents drying out of the surface and minimizes the growth of fungus. I have used black sand (volcanic ash) and rice paddy for this purpose.

After the plant has taken hold in the pot, its growth can be stimulated by applying a small pinch of sulphate of ammonia. The response is immediate and lessens the period they must remain in the nursery.

Eleele and Makaweli, C. F. Poole:

Transplanting from the flats to the paper pots, which were of asphalt felt, 15″ x 6″, fastened with paper clips, was done when the seedlings had about six leaves. Each pot was then marked with waterproof crayon, showing the flat number from which obtained.

The soil used in the pots was the ordinary field soil, which had previously been worked up like a garden patch, spread over with a layer of manure about one inch deep, and washed down with a hose several times before the raw manure was removed.

At Eleele a pinch of ammonium sulphate (A. & B. half and half) was added to the seedlings when growth was resumed after recovering from the shock of transplanting. This recovery varied with individuals and with the time of transplanting. During March it was about forty days, and in June about fifteen days. At Makaweli a small quantity of sodium nitrate was dissolved in water, making a very weak solution, and a few drops were added to the revived seedlings.

No mulch was used in the pots.

Makiki, Y. Kutsunai:

If the fuzz flat is crowded, the bigger seedlings are transplanted rather early, in order to make room for the others. In about four weeks after germination, the seedlings are large enough to transplant to other flats or pots. They are about three-quarters to one inch high and have three leaves.

The soil is composed of one part sand, one part compost, and two to three parts of garden soil. One part well rotted stable manure and one part soil was tried with good results.

Hawi, Kohala, W. C. Jennings:

I transplant in case of either very light or of very heavy germination. If there are but few germinations per flat, too many flats would be needed to care for the desired number of seedlings. If germination is very heavy the seedlings will become too crowded

before reaching the potting stage. When the number of germinations per flat runs from 50 to 100 the seedlings are grown to the potting stage in the germination flats.

The seedlings are transplanted when from 1½ to 2 inches high. I find that the mortality is very high when seedlings smaller than this are transplanted.

The seedlings are shaded for several days after transplanting. After having been shaded from 7 to 10 days, several days more are spent breaking the seedlings into full time exposure to direct sunlight.

When it is necessary to use stable manure or compost in the transplant flats a closely compacted layer about an inch thick is placed on the bottom of the flats and covered with two inches of soil. If the manure is mixed with the soil there is more apt to be trouble with fungi, etc., especially during the period immediately after transplanting when the seedlings must be shaded.

The seedlings are transplanted to pots when from 6 to 8 inches high. My soil mixture for potting is one part manure with three parts of ordinary field soil. The seedlings are shaded and then gradually broken in to exposure to direct sunlight in the same manner as first transplanting.

As soon as the seedlings have recovered from the effects of the potting operation and have started up a good growth, all wind protection is removed. This checks the growth in all the seedlings for a time and while some fail to grow after this check others soon recover and make a vigorous growth. All plants which fail to recover and start up a good growth within 6 to 8 weeks are weeded out.

Control of Insects in the Nursery

Cutworms: Mr. Kutsunai recommends either spraying with lead arsenate solution about once every two weeks or hand picking. Jennings and the writer have found spraying ineffective against cutworms. Continuous hand picking is the only remedy.

Mites and Thrips: Mr. Jennings and the writer have used nicotine sulphate to good advantage. One spraying must be followed in a few days by a second to kill the newly hatched insects.

Control of Fungus: Mr. H. Atherton Lee, pathologist of the Experiment Station, H. S. P. A., recommends a Bordeaux mixture dust for the control of green algae, upon which the fungus gets a start.

Nursery Technic in Other Sugar Countries

Through the cooperation of the cane breeders in other sugar producing countries, the writer is able, through correspondence, to present digests of the methods employed in the nursery. The portion of the quotations which are in italics are ideas which are of particular interest to us and where methods are mentioned might be worth a trial.

I. India

Extract from article written specially for the Committee on Varieties by T. S. Venkatraman, Government Sugar Cane Expert, Coimbatore:

Sowing and Germination: For sowing, shallow, circular country earthenware pans, 12″ across at top, 9″ at bottom and 6″ high, have been found satisfactory. Previous to sowing, the pans are numbered with some waterproof paint. Suitable provision having been made for free drainage at bottom, the pans are filled with a mixture of equal parts of well-rotted horse dung and sand. The fluff is now laid in an even thin layer on the

surface and the first watering done from a garden hose held 3 feet above the pans. The force of the impact gathers round the tiny seeds a small amount of soil and this facilitates germination. The quantity of water employed should not be of such as to form a pool in the pan as it leads to the seeds all getting to one side and germination is affected. Immediately after sowing the pans are arranged in groups, each group containing all the pans of a particular lot, and each group is separately labelled with details as to variety sown, date of sowing and other details. *For this purpose paper labels first written in pencil or India ink and subsequently dipped in melted paraffin wax have been found useful; they are unaffected by the frequent watering.* Germinations have not been noticed earlier than three days from sowing; and pans not germinating within a fortnight have rarely been found to do so later.

Watering: At Coimbatore, it has been found necessary to water the pans as often as three to four times during the day. The watering is always done through a garden hose. For proper germination it has been found necessary to keep the fluff always moist. After germination the plants need much less water as the roots quickly develop and traverse a good bit of soil. The young cane plants are often very susceptible to excess of water and quickly turn yellow.

Precautions During Early Stages: It has been found useful to place the seedling pans on raised bamboo platforms about 2½ to 3 feet from the ground. Besides facilitating constant inspection of the young plants, the arrangement is of use against ants and crickets. *It has been found best to place the seedlings in full sun. The young sugar cane plants appear to revel in full sun and are rather susceptible to any kind of shade. In one instance the circular shade from a cocoanut crown marked off a corresponding circle of weak and unhealthy plants in the pans placed under it.*

Weeding and Thinning of Sown Pans: The appearance of a large number of grass seedlings, which in the earlier stages look much like those of the cane and hence are difficult to weed out is a trouble of some importance. At Coimbatore, the two weeds chiefly met with in the pans are *Chloris barbata* and *Cynodon dactylon.* It was found that the number of these could be greatly minimized if the horse dung, which is apparently the chief source of infection, is pitted for a couple of months before use and periodically watered. The heat generated in the pits appears to cause the death of the grass seeds. As an additional precaution the filled pans are allowed to remain unsown from ten to twelve days and occasionally watered during the period. The grass seedlings that come up are pulled out and the pans are now ready for sugar cane growing. The very few grass seedlings that appear even after the above precautions are easily removed by trained laborers. Should the pans be found very crowded, and contain, say, more than two or three hundred seedlings, they need pricking after a fortnight into a second set of pans. If the germination is thinner the pans may be left till they are ready for planting in the first ground nursery.

II. Java

Extracts from translation of Handbook of Sugar Cane Culture, Chapter VII, page 323:

'*Seeding, Nursing and Planting Out:* The flowers may now be planted right away by picking the small ears or by letting the individual little flowers drop off, or by leaving the entire flowers in a box out in the sun. Naturally a wind-still place must be selected, as otherwise too much of the seeds are lost. In the early morning when there is no wind, the woolly mass is spread out on a previously prepared spot where the soil has been loosened and powdered. This spreading out in a thin layer can best be done with a thin rod, which is a much quicker way than to put down each individual flower. The seed is then pressed in the soil with a small board and covered with fine soil from a sieve, just enough to keep the seed down. Too deeply buried seed does not germinate. When this is

done water is applied from a sprinkling can with small holes, and this must be repeated daily and often enough to prevent the seed from drying out.

Moquette began with the seed spread out in boxes with sand, kept in the shade and well moistened. After four days the first germs appeared, but many of the small plants withered in a few days. They received too little sunshine, and experienc showed later that they did better in heavy soil than in the river sand.

Therefore, when seedling cane, a fertile soil, plenty of moisture and sunshine are first essentials.

Seeding may also be done on plots directly on the field, but moles and other vermin can easier be kept out when the seed is put in boxes. Preferable for use are the flat boxes, large pots or the flat square clay trays such as first used by Souit. To facilitate controlling the trays they may be put up on a framework which at the same time protects the tiny plants from the attack of the many insects living on the surface of the soil. It eliminates carrying back and forth of loose covers.

Application of stable manure, however desirable for young plants, is bothersome on account of the large number of weeds that must quickly and repeatedly be removed. This is again undesirable because the young cane shoots resemble so closely the grass plants that only a trained eye can see the difference. Therefore it is better to sprinkle the soil with a weak solution of ammonia or nitrate of soda, either previous to seeding, or a few days later. For strength a tablespoonful in a kerosene can is sufficient. This may be repeated several times if necessary. The beneficial effect may easily be noticed by observing the dark green coloring and the quicker growth of the plants. Although the number of weedings may thus be reduced, it cannot be eliminated altogether. To do this most effectively is by means of a pair of scissors; the germinating sprouts of the double seed lobe plants must be cut just a little under the seed lobes, and those of the grasses right under the soil. Doing it this way prevents loosening of the soil, and the young cane shoots escape harm. Another way of avoiding the germination of weeds is by preparing the trays a long time beforehand and working the soil over. The weeds do not then get a chance to come through. The soil must be kept moistened.

III. Philippine Islands

Reply to questionnaire received from Professor N. B. Mendiola, University of the Philippines, College of Agriculture, Los Banos, Laguna:

I am using two kinds of seed boxes for germination and pre-transplanting cultures—a shallow one where the soil is about 10 cm. (4 inches) deep for germination and a deeper one where the soil is not less than 15 cm. (6 inches) deep for pricking the seedlings into. Both are of the same length and width, are easily obtained by dividing a Standard Oil petroleum box into two, and providing the sides, which were once the top of the box with covers. The soil I use is rich in organic matter and *is first sterilized on an open pan above a fire.* The germination boxes are fully exposed to direct sunlight more than half of the day. The fuzz is shaken off the arrow or pulled off it and allowed to drop onto the surface of the soil in the seed box. The seeds are sown thickly, covering practically all the surface. The box is then watered thoroughly and covered with a piece of glass. Watering is done subsequently every day, morning and afternoon, or often enough to keep the box moist. *The glass is not whitewashed. However, a piece of cloth covers the top of the glass. This cloth is used to maintain a desirable amount of sunlight in the box and is rolled up when the sun is not too bright to heat the seed and seedlings to the wilting or danger point.* As stated elsewhere, germination is done in the shallower box. As fast as the seeds germinate they are picked into boxes where the soil is 15 cm. or more deep. These boxes are 35 x 49 cm. in the inside and contain 24 pricked seedlings each. I have so far made no determination of percentage of germination. The seedlings are allowed to grow in these boxes until transplanted into nursery rows in my Plant Breeding Garden. At transplanting time the

seedlings are about 35-40 cm. high. I have not done any fertilization work either when the seedlings are in the boxes or in the nursery rows or when these are in propagation cultures in the field. Provided the newly transplanted seedlings are given sufficient water every day there is no need of covering them from too intense sunlight. When water is not available in sufficient quantities for watering the seedlings, I found it necessary to cover the newly transplanted seedlings with pieces of the false stem of the banana plant until the plants are recovered.

IV. Mauritius

Reply to questionnaire by C. A. O'Connor received from H. Temparary, Director of Agriculture:

The boxes employed for sowing seeds are from ordinary empty kerosene cases cut in two. They are about 1′ 9″ long and 1′ 2″ wide and 5″ high, there are a certain number of holes at the bottom for drainage. *A layer of small gravel is placed at the bottom to prevent the soil clogging drainage holes.* These boxes have the advantage of being light, they can be easily carried about by one man, even after having been filled with soil.

The soil used is always burnt in order to destroy grass and weed seeds. The cane seedlings can easily be recognized as soon as they appear, by the tendency they have of growing in a slanting position.

Germination is very liable. Some varieties, especially those raised from seeds, will themselves yield very fertile seeds, whilst others, like the "White Tanna," give poor results. It has been noticed that seeds of the same variety collected from different districts give different results. Those collected from one locality yielding hundreds of seedlings and those from another place one or two plants or often none at all. This is attributed to the effect of wind and rain at the time of flowering. As a rule tassels obtained from a dry district are more fertile than those from a wet one.

When the boxes are ready the fuzz is spread thinly on the soil. It is then pressed gently with the hand and covered with a thin layer of fine coral sand. After sowing the boxes are watered with a garden syringe giving a fine spray, in order not to disturb the seeds. The boxes are placed on stone or iron shelves as a protection against hares, tenrecs (Centetes sps.), snails, etc.

The sand prevents the soil cracking and baking. We do not find that it promotes the growth of fungi, if there is proper drainage. The boxes are at times covered with glass panes to check evaporation. They are watered from time to time. The soil must be kept moist, but not too damp. Germination begins about 15 days after sowing.

When the seedlings are about a month old, they receive a pinch of sulphate of ammonia to stimulate growth.

The seedlings are transplanted into bamboo or earthenware pots when they have five or six leaves. Only healthy plants are selected, all weak ones are discarded.

Insects and fungi are kept in check by application of tobacco, Bordeaux mixture or other sprays.

When seedlings appear to be getting too big for their pots, they are again transplanted in the field in rows 5′ apart and 2½′ in the rows.

V. Fiji

Extract from article given to writer personally by H. F. Clark, Agriculturist, Colonial Sugar Co.:

Soil is a rich alluvial-loam. It is sieved through a fine-meshed sieve and baked, i. e., it is kept for about half an hour on an iron plate over an open fire at a temperature at which slight charring occurs in the organic matter it contains. *It is then cooled, put into*

boxes, and worked up with liquid manure for a couple of weeks before being used. The "fuz" is sown by spreading it evenly over the surface of the dry soil and pressing it well down. It is watered several times a day for the first few days. Germination begins in 3 or 4 days; is at its best in 7 or 8 days, and is generally completed in 14 days.

Germination: Germination and early growth are carried out in a glass-house. This is merely a suntrap, and is not steam-heated. The temperature ranges from 90° F. to 120° F. during the daytime, but it drops to between 60° F. and 70° F. during the night.

Potting Out: When the seedlings are 1″-1½″ high they are planted out into 6″ pots. They are kept a few more days in the glass-house, and are then transferred to cold frames. They are covered with canvas at night till the seedlings have hardened a little.

Planting Out: When the seedlings are 8″-12″ high, they are planted out into the field into drills 5′ apart. The seedlings are set out at 5′ from one another in the drills.

Manuring: Sulphate of ammonia is occasionally applied before the seedlings are potted out. A very light dose is given while they are in the pots, and a somewhat larger one after they have been planted out in the field for a few weeks. No other fertilizer is used. The first land into which the seedlings are planted is a rich alluvial-loam.

VI. Australia

Reply to questionnaire received from H. T. Easterby, Director Bureau of Sugar Experiment Stations, Queensland:

We use shallow boxes of rich, loamy, porous, sterilized soil; pull fuzz to pieces over the boxes; percentage of germination from 5 to 80 per cent, according to warmth of season. Use glass covers with cheese cloth. On very clear days a double cover is used. We transplant at 4 months into large boxes with about 8 inches of soil. We do not use fertilizer.

VII. Porto Rico

Reply to questionnaire received from T. F. Saldana, Assistant Horticulturist, Porto Rico Agricultural Experiment Station, Mayaguez:

Mode of procedure in the nursery: Flats 14¼″ x 19″ x ⅜″ are used. Five holes are made in the bottom of each flat for drainage. For planting the fuzz we use sandy loam river soil which has been passed through a one-fourth inch mesh sieve. The flats are filled with this soil and then packed back to within 1 inch of the top edge. They are watered so that when the fuzz is planted it will stick to the soil. The fuzz is shaken all over the flats until a uniform thin layer, not more than ¼ inch thick, is obtained; they are then watered again with a watering can having a fine nozzle so as to pack down the fuzz. The packing down is also done with the palm of the hand. We have tried covering the fuzz with a very fine layer of finely screened soil, but observation shows us that a stronger germination is obtained when no covering is used. In order to avoid mixing the planting is done in a draft proof house, and each variety when planted is taken out immediately before fuzz from another is seeded down. Watering is done twice a day, morning and night. Germination begins at from 6 to 17 days, depending on variety and vitality of seed used.

The young seedlings have been submitted to different conditions during the past year. A shed house partially covered with palm leaves did not serve the purpose on account of the fact that during rains the water fell in big drops, disturbing the soil around the seedlings. A glass roof green house, the walls of which consisted of ¼ inch mesh netting wire, has given good results. After the seedlings have been transplanted to boxes or pots we seldom give them extra protection. For transplanting the young seedling from the seed flats we have used bamboo pots, and 10-inch clay pots. Also flats of the same

dimensions as those used for germinating the seed are used, planting 20 seedlings to each pot, but on account of the expense of using thousands of pots, we have adopted the flats for most of the work. The seedlings are transplanted when they are from 1 inch to 1½ inch high, i. e., when they are about one month old. The soil we use for transplanting the seedlings consists of 2 parts river loam and 1 part stable manure. The seedlings are watered twice a day for the first week and from then on only once daily. They are watered about once or twice a week with nitrate of soda water at the rate of 4 grams to a gallon of water. They are grown about a month under these conditions and then transplanted to the field, in rows 5 feet apart and with 3 feet between the plants in the rows.

VIII. British Guiana

Notes by F. X. Williams, November, 1923, at Sugar Planters' Experiment Station at Sophia, Georgetown, Mr. T. J. Crabtree, Superintendent:

Apparatus and Methods: Seeds are taken off the "arrows." Seedling boxes, good size, 2 inches or so deep. Soil used sterilized so as to eliminate the growth of weeds. *Bottom of box filled with coarse burnt earth lumps, finer above this and finally fine soil.* Seeds laid mat-like on top and then preferably weighted down with a little sand. In 5-6 days seedlings appear; *those late in germinating are weaklings.*

Cane Loaders*

By B. W. Mackie

The most practical device used in loading cane into cars in the field has proven to be a full revolving crane, or derrick, mounted on a tractor base of the crawler or continuous tread type. The cane is bundled or piled onto a pair of single slings lying on the field, and the bundles lifted by the crane, swung around to the car and dropped. The slings are removed after being unhooked, and pulled free from the bundle by the crane.

The machine itself consists essentially of a *tractor* or *crawler base,* on which are grouped the traveling and steering mechanisms controlled by the operator from the operating platform on the rotating base. The *rotating base,* mounted on the tractor base, contains the *power plant, hoisting and swinging mechanisms,* the *control levers,* and a *boom* approximately forty feet long, capable of being raised or lowered as desired.

In getting over the fields it is important that the machine have sufficient effective length and breadth supporting it, so that it will be stable. Ten by ten feet seems to be about the accepted size. Taking this as a basis from which to build a strong and rugged machine, it is found that the total weight will be somewhere between 20 and 25 tons. To move this weight over the field with as little damage as possible, the crawler type tread must have sufficient supporting surface to dis-

* Presented at the Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

tribute the total weight over a large area. The bearing pressure on the ground should not exceed 10 pounds to the square inch.

Cane loaders of this type are not limited to just this one class of work, as they may be used for operating a clamshell bucket, dragline scraper bucket, hook block, pile driver hammer, electric lift magnet, etc. Nearly every type made may be converted into a power shovel, by taking off the crane boom and substituting a boom having the proper equipment for this work. The machine can then be used for the same work that a steam shovel would be used.

Essential Machine Parts

Power Plant: The power plant of a cane loading crane usually consists of a heavy duty tractor type gasoline engine having four cylinders. It should develop sufficient power at a normal speed to drive the machine anywhere it would be expected to work. All its parts must be built rugged and strong, with special reference to accessibility and perfect lubrication. It is important that an air cleaner be installed ahead of the carburetor to insure against grit and dirt entering the engine. A clutch should be installed between the engine and operating mechanism so all gears and shafts may be stopped with the engine still running. The power plant should be mounted on the main frame in such a manner that all strains are not directly transmitted to the engine base. The drive to the reduction gears should be as flexible as possible. An efficient cooling system is imperative.

Drive From Power Plant: Because of the fact that a gasoline engine develops its power at a relatively high speed, a means of reducing this speed to that required for hoisting, swinging, and traveling, must be employed. This reduction is accomplished usually by gears. Special attention should be paid to securing a drive which will give perfect service in operation.

Rotating Mechanism: The rotating frame is swung to right or left by a pinion engaging in a ring gear fastened to the travel base. The rotating pinion, through a series of reductions, receives its power from a reversing shaft driven from the reducing gears. Where only one reversing shaft is employed, a jaw clutch is mounted on the rotating shaft so that it may be disengaged, and the reversing shaft used for traveling. There is no necessity in this work to perform swinging and traveling simultaneously, so the use of two separate sets of reversing clutches is done away with. One set, through selective jaw clutches, enables the operator to handle the machine under all operating requirements. Simplicity of design and accessability for repairs is important.

Hoisting Mechanism: The hoisting mechanism consists of drums independently driven by friction clutches, loosely mounted on shafting driven from the reduction gears. Where both drums are mounted on one shaft, the design is simplified by the elimination of a shaft, bearings and a gear, and makes other assemblies easier to get at. It is necessary to see that the drums be of sufficient size to properly coil the two hundred feet of one-half-inch cable, commonly used for hoisting.

The Propelling Mechanism: This drive is taxed with the hardest service at all times. It must be rugged and contain the least number of pinions, gears, and shafts possible. It must be constructed so that repairs in the field can be readily made. The drive is taken from the reversing clutches, through several gear reduc-

tions and the center pin of the machine, to the travel base, and finally to the crawler treads themselves. The final drive to the treads is either through gears or a roller chain. The chain drive is the most flexible and easiest to repair, and in addition gives adjustment of the tread belt at either end of the travel base.

Rotating Base: The main rotating member is called upon to withstand severe shocks due to traveling over uneven footing, ditches, etc., and is preferably made of a solid annealed steel casting, from which the supports for the main machinery are built up.

Travel Base: The travel base, which must be built very rugged and strong, consists of a *heavy main casting,* preferably steel, the *supporting axles or beams* for the crawler treads, and the *ring gear* securely attached to the casting. Avoid any machines that have built-up structural bases for the main parts of either the rotating or traveling bases.

Center Pin: The travel base and rotating base are tied together by means of a hollow steel gudgeon or center pin, which must be of the best material obtainable and heavy enough to afford a good margin of safety. There must be provided a convenient means for taking up wear at this point of the machine.

Treads: There are many types of crawler mechanisms, but the ones that most closely follow approved tractor ideas will be found to be most satisfactory.

General: It is, of course, highly important that workmanship and careful design enter into a machine of this nature, to insure the greatest degree of service. Interchangeability of parts is also an important feature. Levers and controls must be placed so that all operations can be conveniently performed by the operator from his platform. Proper lubrication of all bearings is essential to insure long life and continued service. The use of frictionless bearings on high speed shafts and gears is to be recommended. Placing the operator so that he commands an unobstructed view on all sides and providing controls that will operate with the least physical effort, will make possible performing the greatest amount of work. Adjustments must be provided at all points in the controls to compensate for wear.

Cane Field Conditions From the Standpoint of Machines

Traveling: Cane loaders in the field are subjected to the hardest kind of service, in that they are moving from car to car a great percentage of the time, under unfavorable ground conditions. Furrows, irrigation ditches, and water course ditches, encountered at all times, necessitate a strongly built foundation, and only the best construction will endure. It is important that the machines go over the fields with as little disturbance as possible, and with despatch. Quite frequently the machines are called upon to work on a grade, and some form of brake on the travel mechanisms is required, or they must be blocked to prevent rolling down grade.

The longer the effective surface of the crawler mechanism on the ground, the more stable will the machine be. A short crawler tread will, in effect, give a rocking-horse motion to the machine when traveling across the field. As the field furrows are five feet or more center to center, it will be seen that about ten feet of tread length is desirable.

The treads and driving parts should be so designed as to pick up as little cane trash and refuse lying on the field as possible. This is especially important in wet weather operations.

Careful handling and well-planned setting of the correct number of cars for the amount of bundles to be loaded is essential to satisfactory performance. Requiring the machines to go back over a section already "taken off" to load a few cars can be laid only to bad field management, and works a hardship on the machines because the time taken up in traveling cuts down the total number of cars that can be loaded in one day. Wherever possible, it is advisable to load cane only from the side of the cars on which the machines are traveling.

Steering: Field conditions demand that when turning and steering, the machines do as little damage to the furrows and ratoons as possible. To handle properly they must steer positively to right or left when traveling in either direction, and at the easy command of the operator. A thoroughly successful and practical steering device controlled from the rotating base of the machines is, of course, a necessity. Many machines have a crude and unsatisfactory steering device.

Lifting: All the present machines used in this service have been designed for much heavier work than they are called upon to do in loading cane, so there is a good margin of safety in the hoisting mechanism, and very little trouble, if any, is encountered. A good boom-head construction, for guiding the cable with a minimum of wear, is essential. Also, it is important that the cable wind up properly on the drum with as little attention on the part of the operator as is consistent.

Swinging: It should be the aim of the operators to keep their machines as level as possible when loading cane, so that they will swing easily. This is not always practical in service, so that a powerful, yet easy working, swinging mechanism should be incorporated in the construction. To stop the swinging of the machine, the reversing clutches are thrown in, in the opposite direction, and this should be done in such a manner that the motion is not stopped immediately. After getting the load in motion it should be permitted to coast and be brought to a gradual stop. Gauging the position of the machine with reference to the car to be loaded assists greatly in smooth handling.

Conclusion: The commercial success of the jib crane type of cane loader has been assured by the past season's use at the Oahu Sugar Co., Waipahu; Kahuku Plantation Co., Kahuku; Honolulu Plantation Co., Aiea; The Hawaiian Sugar Co., Makaweli; and Lihue Plantation Co., Lihue. The machines unquestionably relieve the severest manual work on the plantations, and if for no other reason, they are a step in the right direction. The mechanical loaders enable the plantations using them to harvest the cane faster than by hand methods. The use of them assures a train load of cane at the mill earlier in the day. Cane may be bundled in the field whether cars are placed or not, and the cars are kept in actual load hauling a greater percentage of the time.

Cane Varieties*

A Resume of the Plantings for the 1924 Season.

By W. P. Alexander.

The Committee on Varieties submits its report in the form of a survey of the varieties planted and those plowed out during 1924. In this way attention is focused on those commercial varieties and new seedlings which are meeting popular approval under different growing conditions, and those whose acreage is on the decrease. Your committee believes that such publicity on the trend in variety plantings as given in the following notes and statistics should stimulate interest in securing the right variety for each specific environment. Basing our opinion on the results secured from H 109, we feel justified in stating that the greatest opportunity for advancement in the agricultural side of the industry is through the breeding and selection of the best varieties.

In preparing this report the cooperation of the different managers has been secured, and the following committeemen have assisted materially: Oahu, F. A. Paris and Y. Kutsunai; Maui, W. W. G. Moir and Frank Broadbent; Hawaii, J. C. Thompson.

The data have been divided into two sections, viz:

(1) Commercial plantings of varieties.
(2) Experimental plantings of varieties.

It is treated geographically, for it is the conditions on the different Islands and on the individual plantations that determine what variety is to be planted. The relative distribution of each variety taken as a whole throughout the Islands is of less practical importance to each one of us, than the definite knowledge of what varieties are being grown successfully under certain climatic, soil, and moisture conditions.

COMMERCIAL PLANTINGS

Island of Kauai

Yellow Tip. The outstanding feature in the 1924 variety plantings on the island of Kauai is the replacing of Yellow Caledonia and D 1135 on the mauka lands by Yellow Tip. A total of 2,462.39 acres have been planted to this hardy variety. This represents 32.1 per cent of all the varieties planted. Striped Tip finds less favor, Kilauea, only, planting 63 acres.

All the plantations on the northeast side of the island of Kauai have begun planting their unirrigated lands with Yellow Tip. To quote Mr. John T. Moir, Jr., of Koloa, "Its vigor, stand, and growth rates all point toward a decided eclipse of the old reliable Yellow Caledonia."

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

H 109. As on Oahu and Maui, H 109 is fulfilling all the requirements where irrigation is practiced. There are 4,239.74 acres planted to H 109, which area is replacing mainly Yellow Caledonia, Lahaina, D 1135 and H 146. This represents 55 per cent of all the 1924 plantings on Kauai.

There are not many commercial plantings of other varieties besides H 109, Yellow Tip, and D 1135, which combined account for 89 per cent of the area.

D 1135. D 1135 is "losing ground" with 516 acres plowed out and 222 acres planted during 1924. It will be noted that but 41 acres were started on the windward side of the island. The exposed fields of McBryde occupy the only plantings on the leeward side.

Only 275 acres of Yellow Caledonia are being planted as against 4,874.69 being discarded. Certainly the "death knell" of this old standard variety seems to be sounded on Kauai.

Badila covers a total of 118 acres as plant 1926 cane at Grove Farm, Kipu, and Kilauea. It is not a very popular variety for several reasons, the chief of which is its low fiber content and susceptibility to rat damage.

Uba is being given a trial on 64 acres at Kilauea.

H 20 is being carried on in a small area of 20 acres at Gay & Robinson.

Of the newer Hawaiian seedlings H 456 is being watched. Although the Oahu plantations have found it unsuitable, certainly in the Lihue district it is worth being watched. Kipu planted 50 acres, Grove Farm 5 acres, Makee 18 acres. It will be interesting to observe the ratooning qualities of H 456 on Kauai.

H 463 also is ready to be graduated into the commercial class on this part of Kauai. In tests at Grove Farm good yields have been secured from H 467 and H 468.

ISLAND OF KAUAI.

NUMBER OF ACRES OF DIFFERENT VARIETIES PLANTED DURING 1924.

Plantation	H 109	Yellow Tip	Yellow Cal.	D 1135	Mixed	Badila	H 456	Uba	Str. Tip	H 20	H 463	Str. Mex.	Total Area
Kekaha	450.00	......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	450.00
Waimea	No Plant Cane			.....	.....	.....	.....	.....	.....	.....	.....	.....	......
Gay & Robinson	283.00	......	.....	.....	.....	.....	.....	.....	.....	25.00	.....	.....	308.00
Hawaiian Sugar	790.00	......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	790.00
McBryde	430.00	9.00	15.00	181.00	32.00	.....	.....	.....	.....	.....	.....	5.00	672.00
Koloa	511.00	296.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	807.00
Kipu	10.00	120.00	.....	.....	.....	70.00	50.00	.....	.....	.....	.....	.....	250.00
Grove Farm	158.00	245.00	136.00	20.00	36.00	20.00	8.00	.....	.....	.....	8.00	.....	631.00
Lihue	657.74	692 39	124.55	.....	121.01	.....	.....	.....	.....	.....	.....	.....	1,595.69
Makee	800.00	422.00	.....	.....	.....	.....	18.00	.....	.....	.....	.....	.....	1,240.00
Kilauea	150.00	678.00	.....	21.00	.....	28.00	.....	64.00	63.00	.....	.....	.....	1,004.00
Total Area	4,239.74	2,462.39	275.55	222.00	189.01	118.00	76.00	64.00	63.00	25.00	8.00	5.00	7,747.69
% Area	54.72%	31.78%	3.56%	2.87%	2.44%	1.52%	.98%	.83%	.81%	.32%	.10%	.07%	

NUMBER OF ACRES OF DIFFERENT VARIETIES PLOWED OUT DURING 1924.

Plantation	Yellow Cal.	La-haina	D 1135	H 109	H 146	H 20	Badila	H 227	Fallow or New Land	Total Area
Kekaha	......	450.00	.....	.....	.....	.....	.....	.....	......	450.00
Waimea	......	.....	.....	No Data		.....	.....	.....	......	......
Gay & Robinson	......	70.00	131.00	34.00	24.00	1.00	15.00	13.00	20.00	308.00
Haw. Sugar	......	.....	300.00	.....	100.00	39.00	9.00	.....	342.00	790.00
McBryde	228.00	.....	85.00	352.00	.....	.....	.....	.....	7.00	672.00
Koloa	807.00	.....	.....	.....	.....	.....	.....	.....	......	807.00
Kipu	......	.....	.....	.....	.....	.....	.....	.....	250.00	250.00
Grove Farm	......	.....	.....	.....	.....	.....	.....	.....	631.00	631.00
Lihue	1,595.69	.....	.....	.....	.....	.....	.....	.....	......	1,595.69
Makee	1,240.00	.....	.....	.....	.....	.....	.....	.....	......	1,240.00
Kilauea	1,004.00	.....	.....	.....	.....	.....	.....	.....	......	1,004.00
Total Area	4 874.69	520.00	516.00	386.00	124.00	40.00	24 00	13.00	1,250.00	7,747.69
% Area, Excluding Fallow	75.02%	8.00%	7.94%	5.94%	1.91%	.62%	.37%	.20%	......	

Island of Oahu

H 109 is without question now the standard variety on Oahu. Its leadership among the varieties is shown when, during 1924, 98 per cent of all the plant area, of seven plantations reporting, was in H 109. Ewa plantation replaced 616.31 acres of old H 109 ratoons with the same variety, which is evidence that the variety has no rival there.

D 1135 was not planted anywhere, while 608.35 acres were plowed out. H 146 lost 257.46 acres and none planted.

Yellow Caledonia was plowed out on 1,679.18 acres, and Lahaina on 1,538 acres. They represent 65 per cent of the area plowed out and there will soon be very little of either variety on the island of Oahu.

Of the newer seedlings H 8958 was spread to 2 acres on Oahu Sugar Co. and Wailuku No. 2 was planted to 5 acres at Kahuku.

ISLAND OF OAHU *

NUMBER OF ACRES PLANTED TO DIFFERENT VARIETIES DURING 1924

Name of Plantations	H 109	Y. C.	Wailuku 2	Lahaina	H 8958	Seedling Nurseries	Total
Honolulu Plantation	1,061.00	.....	.....	.....	2.00	1.25	1,064.25
Oahu Sugar	1,086.43	.....	.....	.....	.....	.....	1,086.43
Ewa Plantation	604.86	.....	.....	.....	.....	21.25	626.11
Waialua Agricultural	1,646.60	.....	.....	.....	.....	.....	1,646.60
Kahuku	373.75	.....	5.00	3.25	.....	3.00	385.00
Laie	85.00	57.50	.....	.....	.....	.....	142.50
Koolau Agricultural	100.00	.....	.....	.....	.....	.....	100.00
Total Acreage*	4,957.64	57.50	5.00	3.25	2.00	25.50	5,050.89
Per cent of Acreage*	98.16%	1.14%	0.10%	0.06%	0.04%	0.50%	

* No acreage data from Waianae and Waimanalo.

ISLAND OF OAHU *

NUMBER OF ACRES PLOWED OUT OF DIFFERENT VARIETIES DURING 1924

Name of Plantation	Y. C.	Lahaina	H 109	D 1135	H 146	Badila	Mixed	Fallow or New Land	Total
Honolulu Plantation	948.00	19.00	.....	96.00	....	....	.....	1.25	1,064.25
Oahu Sugar	......	671.94	.....	330.14	72.85	11.50	.....	.....	1,086.43
Ewa Plantation	......	4.41	616.31	.....	....	....	.....	5.39	626.11
Waialua Agricultural	215.18	842.71	.....	182.21	184.61	....	221.89	.....	1,646.60
Kahuku	339.00	......	.....	.....	....	....	.....	46.00	385.00
Laie	77.00	......	.....	.....	....	....	.....	65.50	142.50
Koolau Agricultural	100.00	......	.....	.....	....	....	.....	.....	100.00
Total Acreage*	1,679.18	1,538.06	616.31	608.35	257.46	11.50	221.89	118.14	5,050.89
Percentage of variety areas plowed out*	34.05%	31.18%	12.49%	12.33%	5.22%	.23%	4.50%		

* No acreage data from Waianae and Waimanalo.

Island of Maui

The stronghold of Lahaina has fallen to H 109. The Maui plantations, which sent in data, report 91 per cent or 5,166.43 acres planted to H 109 with but 2 per cent or 108 acres planted to Lahaina.

Striped Mexican was spread to 258 acres, with 454.2 acres plowed out.

Badila was planted to 25 acres.

Rose Bamboo, H 146, D 1135 and Yellow Caledonia are being rapidly discarded.

On a small scale newer seedlings such as Wailuku 2 and Wailuku 4 are finding favor.

ISLAND OF MAUI *

NUMBER OF ACRES PLANTED TO DIFFERENT VARIETIES DURING 1924

	H 109	Striped Mex.	Lahaina	D 1135	Badila	W-2	W-4	Mixed	Total
Maui Agri.....	1,570.00	250.00	95.00	.....	25.00	.....	.....	.....	1,940.00
H. C. &. S. Co..	1,521.00	.....	13.00	16.00	.....	.....	.....	.....	1,550.00
Pioneer.......	1,500.00	8.00	.....	.....	.....	.....	.....	5.00	1,513.00
Olowalu.......	24.50	.....	.....	.....	.....	.....	.....	.....	24.50
Wailuku......	550.93	.....	.....	55.16	.....	25.00	20.00	6.00	657.09
Total Acreage*	5,166.43	258.00	108.00	71.16	25.00	25.00	20.00	11.00	5,684.59
% of Acreage..	90.88%	4.54%	1.90%	0.44%	1.25%	0.20%	0.44%	0.35%	

* No acreage data from Kaeleku.

ISLAND OF MAUI *

NUMBER OF ACRES PLOWED OUT OF DIFFERENT VARIETIES DURING 1924

	Lahaina	H 109	D 1135	Bamboo	Str. Mex.	Y. C.	H 146	Fallow or New Land	Total
Maui Agricultural....	615.00	311.00	72.00	221.00	124.00	52.00	....	545.00	1,940.00
H. C. & S. Co........	323.00	401.00	163.00	.....	.....	.....	.....	663.00	1,550.00
Pioneer	933.00	22.00	.....	.....	.....	8.00	25.00	525.00	1,513.00
Olowalu	22.00	.....	.....	.....	2.50	.....	.....	.....	24.50
Wailuku	49.56	.....	.....	.....	327.70	63.24	68.85	147.74	657.09
Total Acreage*	1,942.56	734.00	235.00	221.00	454.20	123.24	93.85	1,880.74	5,684.59
Percentage of variety areas plowed out*...	51.07%	19.30%	6.18%	5.81%	11.94%	3.24%	2.46%		

* No acreage data from Kaeleku.

Island of Hawaii—Kau District

D 1135 and Yellow Caledonia continue to remain the standard varieties of the Kau district, planting 52.5 per cent and 47.5 per cent respectively of the 1924 area. At Pahala, where cane is grown at the highest elevations, Yellow Caledonia has given 70 tons of cane at 2,000 feet elevation, and D 1135 the same yield at 2,600 feet.

Rose Bamboo, Yellow Bamboo and White Bamboo are being plowed out. The Tip canes have not found favor in the Kau district.

ISLAND OF HAWAII—KAU DISTRICT

NUMBER OF ACRES OF DIFFERENT VARIETIES PLANTED DURING 1924

Plantation	D 1135	Yellow Caledonia	Total
Hutchinson	120.00	298.60	418.60
Hawaiian Agricultural	424.04	192.95	616.99
Total Acres	544.04	491.55	1,035.59
Percentage of Total	52.53%	47.47%	

NUMBER OF ACRES OF DIFFERENT VARIETIES PLOWED OUT DURING 1924.

Plantation	Rose Bamboo	Yellow Bamboo	White Bamboo	Striped Tip	Yellow Cal.	Total
Hutchinson	220.60	.....	.....	60.00	25.00	305.60
Hawn. Agric....	......	98.00	97.00	.....	.....	195.00
Total Acres	220.60	98.00	97.00	60.00	25.00	500.60
% Area	44.07%	19.58%	19.38%	4.99%	11.98%	

Island of Hawaii—Hilo District

Makai lands: No cane has been found equal to Yellow Caledonia for the greater part of the Hilo district. From Olaa to Laupahoehoe it was planted this season as it has been for the past 20 years on all the lower and middle fields. No special complaint is made as to its virility taken as a whole, and no seedling has risen to dispute its supremacy.

Mauka lands: On the other hand, a variety is needed that will suit the upper fields as well as Yellow Caledonia does the lower elevations. D 1135 was the most common variety planted this year for these conditions with Yellow Tip running second. There is some difference of opinion as to which variety is to be preferred. It seems that Yellow Tip plantings are on the increase, except at Hakalau, from which place Mr. Geo. Ross, Assistant Manager, writes, "We are trying to get away to a certain extent from Yellow Tip and getting into D 1135. We harvested as high as 60 tons of cane per acre at 1,200 feet elevation with a quality ratio of about 8.5." At Onomea, Yellow Tip is sometimes planted on the knolls and Yellow Caledonia in the hollows. It is considered better than D 1135 and is now being rotated with Yellow Caledonia on mauka fields.

The plantations along the Hilo coast realize that they should add to their three standard commercial varieties Yellow Caledonia, D 1135 and Yellow Tip.

The following notes on 1924 plantings show canes that are passing beyond the experimental stage:

At Waiakea, Badila (4 acres), Waiakea No. 1 (1 acre), H 109 (1 acre), H 8958 (1 acre) were planted in 1924.

At Hilo Sugar Co., H 389 (4.14 acres), H 109 (1.02 acres) and Badila (.5 acre) were planted in 1924.

At Onomea, there are H 456, H 469, H 471, H 472 and Wailuku No. 2.

At Honomu, there were extended this year Badila (2 acres), D 117 (8 acres), Striped Mexican (1 acre), White Bamboo (2 acres) and Rose Bamboo (2 acres).

At Hakalau, H 109, H 456, H 457 and H 463 are mentioned. Most of the above canes are doing well on the high elevations. H 227 is being discarded in the Hilo district, especially at Olaa.

ISLAND OF HAWAII—HILO DISTRICT.

NUMBER OF ACRES OF DIFFERENT VARIETIES PLOWED OUT DURING 1924 (Incomplete).

Plantation	Y. C.	H 227	Striped Tip	Yellow Tip	Total
Pepeekeo	591.00	.....	.....	9.00	600.00
Hilo Sugar Co.............	431.87	.....	.....	.....	431.87
Waiakea	320.50	0.5	22.00	.....	343.00
Olaa	......	124.00	.....	.....	124.00
Total Area 4 Plantations...	1,343.37	124.50	22.00	9.00	1,498.87
% Area	89.63%	8.30%	1.47%	0.60%	

No data on acreage plowed out from Hawaii Mill, Onomea, Honomu, Hakalau and Laupahoehoe.

ISLAND OF HAWAII—HILO DISTRICT

NUMBER OF ACRES OF DIFFERENT VARIETIES PLANTED DURING 1924 (Incomplete)

Plantation	Yellow Caledonia	D 1135	Yellow Tip	Mixed	D 117	Badila	H 389	Black Tanna	H 109	White Bamboo	Rose Bamboo	Waiakea No. 1	H 8958	Striped Mexican	H 456	Uba	Total Area
Waiakea	782.00	15.00	19.00	2.27	...	4.00	...	3.00	1.00	...	...	1.00	1.00	...	...	...	828.27
Pepeekeo Sugar	541.00	25.00	34.00	....	...	...	...	...	...	...	...	...	...	...	...	...	600.00
Olaa	348.00	178.00	....	....	...	...	...	...	...	...	...	...	...	...	...	...	526.00
Hilo Sugar Co.	264.50	153.18	8.00	.53	...	.50	4.14	...	1.02	...	...	...	...	...	...	...	431.87
Honomu Sugar	.....	28.00	21.00	8.00	8.00	2.00	...	...	...	2.00	2.00	...	...	1.00	1.00	.50	73.50
Total 5 plantations*	1,935.50	399.18	82.00	10.80	8.00	6.50	4.14	3.00	2.02	2.00	2.00	1.00	1.00	1.00	1.00	.50	2,459.64
% Area	78.70%	16.23%	3.33%	.44%	.33%	.26%	.17%	.12%	.08%	.08%	.08%	.04%	.04%	.04%	.04%	.02%	

* No data on acreage of each variety planted during 1924 from Hawaii Mill, Onomea, Hakalau and Laupahoehoe.

Island of Hawaii—Hamakua District

The 1924 plantings in the Hamakua district consisted mainly of D 1135 (61 per cent), Yellow Tip (23 per cent), Yellow Caledonia (12 per cent) and Uba (2.3 per cent). They replaced chiefly Yellow Caledonia (44.5 per cent), D 117 (37.5 per cent), D 1135 (8.54 per cent), Striped Tip (5 per cent) and H 109 (4 per cent).

The choice of varieties depends largely on the elevation and mosaic disease conditions on the plantations. Yellow Caledonia is not planted much above the 600-foot elevation and D 1135 may be put in on the lower lands, and also going as high as 1,200 feet. Yellow Tip seems to be a favorite for the highest fields, except at Honokaa and Pacific Sugar Mill where yellow stripe disease or mosaic is prevalent. Uba, which is resistant to mosaic, is being tried to meet these conditions, and appears to have passed the experimental stage at Honokaa, as the following comparative yields with D 1135 show:

Variety	Crop Area	Cane	Q. R.	Sugar
Uba	.60	68.30	16.33	4.14
D 1135	139.00	37.92	9.56	4.17
Difference		+30.38	— 6.77	+0.03
Uba	9.00	47.7	8.01	5.67
D 1135	137.00	35.6	7.84	4.57
		+12.1	— 0.17	+1.10

Yellow Caledonia is being replaced at Paauhau with the more hardy cane, D 1135.

H 72 was spread to 2 acres at Paauhau and H 349 to 5 acres at Kaiwiki.

At Honokaa, several new promising seedlings appear on the horizon. An unselected seedling of the 1917 Oahu propagation No. 229 now known as Honokaa No. 1 is planted to 15 acres. The new Uba-D 1135 Hybrid No. 1 now covers 4 acres at Honokaa and Pacific Sugar Mill.

ISLAND OF HAWAII—HAMAKUA DISTRICT

NUMBER OF ACRES PLANTED TO DIFFERENT VARIETIES DURING 1924

Plantation	D 1135	Yellow Tip	Yellow Caledonia	Uba	Honokaa No. 1	D 117	Seedling Nursery	H 349	Uba Hybrid	H 72	Total Acres
Kaiwiki	504	55	205	....	...	12	...	5	...	...	781
Hamakua Mill	480	256	150	....	...	...	...	...	...	...	886
Paauhau	426	343	...	....	...	...	...	...	...	2	771
Honokaa	30	....	...	50	15	...	6	...	2	...	103
Pacific Sugar	300	....	...	16	...	...	3	...	2	...	321
Total Area	1,740	654	355	66	15	12	9	5	4	2	2,862
% Area	60.81%	22.85%	12.40%	2.31%	.52%	.42%	.31%	.17%	.14%	.07%	

NUMBER OF ACRES PLOWED OUT TO DIFFERENT VARIETIES DURING 1924

Plantation	Yellow Caledonia	D 117	D 1135	Striped Tip	H 109	H 75	H 349	Badila	Fallow or New Land	Total Acres
Kaiwiki	432	185	25	118	....	6	3	...	12	781
Hamakua Mill	....	740	....	....	....	...	...	...	146	886
Paauhau	426	....	185	....	....	...	...	...	160	771
Honokaa	2	....	....	....	15	...	...	1	85	103
Pacific Sugar	236	....	....	....	85	...	...	...	...	321
Total Area	1,096	925	210	118	100	6	3	1	403	2,862
% Area Without Fallow	44.57%	37.62%	8.54%	4.80%	4.07%	.24%	.12%	.04%		

Island of Hawaii—Kohala District

The variety situation in Kohala did not change much during the 1924 season. Periodic dry spells make it absolutely necessary to have a drought-resistant variety of cane. H 109, therefore, can only be planted where irrigation is practiced. Even Yellow Caledonia is not able to withstand the extreme droughts as it once did. D 1135 for the middle and lower section and Yellow and Striped Tips for the upper fields compose the commercial plantings for 1924. The presence in Kohala of mosaic and red stripe diseases which attack the Tip canes makes it very important that a substitute that will do equally as well as Yellow and Striped Tip be found.

ISLAND OF HAWAII—KOHALA DISTRICT.
NUMBER OF ACRES OF DIFFERENT VARIETIES PLOWED OUT DURING 1924 (Incomplete).

Plantation	Y. C.	Striped Tip	H 109	D 1135	Striped Mex.	Total
Hawi Mill	235.00	265.00	177.00	107.00	4.00	788.00
Union Mill	60.00	.....	.....	.....	.....	60.00
Total Area	295.00	265.00	177.00	107.00	4.00	848.00
% Area	34.79%	31.25%	20.87%	12.62%	0.47%	

No data on varieties plowed out during 1924 from Niulii, Halawa and Kohala.

ISLAND OF HAWAII—KOHALA DISTRICT

NUMBER OF ACRES OF DIFFERENT VARIETIES PLANTED DURING 1924 (Incomplete)

	Striped Tip	D 1135	Yellow Tip	H 109	Mixed	Uba	Total Area
Union Mill	484.00	63.00	....	....	...	...	547.00
Hawi Mill	139.00	263.00	85.00	50.00	7.00	1.50	545.50
Total area*	623.00	326.00	85.00	50.00	7.00	1.50	1,092.50
% Area	57.02%	29.84%	7.78%	4.58%	.64%	.14%	

* No data on acreage of each variety planted during 1924 from Niulii, Halawa and Kohala.

Experimental Plantings for 1924

The experimental work on varieties is largely in the hands of the Experiment Station of the H. S. P. A. They may furnish the varietal material, but they must rely on the plantations themselves to undertake the testing under different field conditions. After it has passed the experimental stage the development of new varieties on a commercial scale rests entirely with the plantations.

The disappointments in new seedlings have been so many that caution is needed in not letting one's enthusiasm for a "pet seedling" run wild. A thorough trial on large enough areas of repeated plots, with check areas of a standard variety, is necessary to secure proper comparisons. Fields of plant cane are very misleading. Time is required to get the ratooning qualities with sucrose content of a seedling growing to maturity in 20 months, but such information is very important. There would be less overrating of new seedlings if more patience were exercised and one waited for harvesting data together with comparative yield of the adjacent standard variety. It is not merely enough that a variety looks "promising," its sucrose content, ratooning qualities, disease resistance, and time of maturity must be known.

The following notes are not a complete digest of the variety work being done. Unfortunately the replies to the committee's questionnaire on new seedlings were very brief. Nevertheless, there is a very good indication of the present status of the Hawaiian seedlings:

Older "H" Seedlings (Excluding H 109)

Kauai—

H 20 is the only one of the older "H" seedlings which is reported as being spread during 1924, 25 acres being planted on Kauai at Gay & Robinson.

Concerning this variety Mr. Sinclair Robinson writes as follows:

> For early season harvesting our H 20 has in a number of instances proved better than adjoining areas of H 109. As our fields are harvested each year prior to April 1, we have therefore considered it advisable to continue further experiments with the variety H 20. Lack of good top seed, however, makes it a difficult cane to start, but so far our ratoon fields have fully compensated for the additional expense in planting.

H 146 will soon be extinct at the rate large areas are being plowed out.

Oahu and Maui—

None of these older Hawaiian canes are being experimented with as plant cane for 1926. Large areas of H 146 were plowed out at Oahu and Waialua and a small acreage at Pioneer.

Hawaii—

Several "H" seedlings of the first series were planted in 1924.
H 72—Paauhau (no harvesting data).
H 349—Waiakea and Ookala (no harvesting data).
H 389—Hilo Sugar Co. reports the following test:

	Cane	Q. R.	Sugar
H 389 plant	72.49	8.94	8.45
H 389 first ratoon	67.29	8.76	7.67
2 crops average	69.89	8.85	8.06
Yellow Caledonia plant	67.02	8.29	8.11
Yellow Caledonia first ratoon	64.98	8.73	7.44
Average	66.00	8.51	7.78
Average gain H 389	+3.89	—0.34	+0.28

H 227 is being plowed out in 1924 on many fields.

"400" Series

Kauai—

H 456. In 1924 the following areas were planted: McBryde, 2 acres; Kipu, 50 acres; Grove Farm, 5 acres; Makee, 18 acres.

Grove Farm reports the following tests with H 456 and Yellow Caledonia:

Variety	Crop	Cane	Q. R.	Sugar
H 456	Plant	76.0	8.39	9.06
H 456	Short ratoon	34.14	7.19	4.75
Average 2 crops		55.07	7.79	6.91
Yellow Caledonia	Plant	73.1	8.78	8.32
Yellow Caledonia	Short ratoon	36.13	8.18	4.42
Average 2 crops		54.62	8.48	6.37
Average gain for H 456		+0.45	+0.69	+0.54

H 457. A test at Grove Farm with Yellow Caledonia is reported:

H 457	Short ratoon	41.97	8.57	4.90
Yellow Caledonia	Short ratoon	36.13	8.18	4.42
Gain for H 457		+5.84	—0.39	+0.48

H 458. A test at Grove Farm is reported:

H 458	Short ratoon	38.50	8.29	4.64
Yellow Caledonia	Short ratoon	36.13	8.18	4.42
Gain for H 458		+2.37	—0.11	+0.22

H 463. A test at Grove Farm is reported:

H 463	Plant	70.1	8.54	8.21
H 463	Short ratoon	47.70	7.53	6.33
Average		58.90	8.04	7.27
Gain for H 463 over Yellow Caledonia		+4.28	+0.44	+0.90

H 467. A test at Grove Farm is reported:

H 467	Plant	67.1	9.84	6.82
H 467	Short ratoon	45.71	8.15	5.61
Average		56.41	9.00	6.22
Gain for H 467		+1.79	—0.52	—0.15

H 468. A test at Grove Farm is reported:

H 468	Short ratoon	42.96	8.14	5.28
Yellow Caledonia	Short ratoon	36.13	8.18	4.42
Gain for H 468		+6.83	+0.04	+0.86

H 469. A test at Grove Farm is reported:

Variety	Crop	Cane	Q. R.	Sugar
H 469	Plant	67.3	9.38	7.17
H 469	Short ratoon	46.79	9.66	4.84
Average		57.05	9.52	6.01
Gain for H 469 over Yellow Caledonia		+2.43	—1.04	—0.36

Oahu—

H 456. Owing to its poor ratooning qualities this variety has not been spread on Oahu during 1924.

A test at Ewa showed this variety cannot compete with H 109.

Variety	Crop	Cane	Q. R.	Sugar
H 109	Plant	106.28	7.63	13.93
H 456	Plant	78.63	7.80	10.08
Gain for H 109		+27.65	+0.23	+3.85

Also at Waipio H 456 failed in 2 crops.

H 109	Plant	77.4	7.44	10.40
H 109	First ratoon	93.3	7.37	12.62
Average 2 crops		85.4	7.41	11.51
H 456	Plant	65.1	7.38	8.82
H 456	First Ratoon	85.9	8.07	10.64
Average 2 crops		75.5	7.73	9.73
Gain for H 109, average 2 crops		+9.9	+0.32	+1.78

H 468. This seedling was compared with H 109 at Ewa in the following test:

Variety	Crop	Cane	Q. R.	Sugar
H 109	Plant	101.50	7.66	13.25
H 468	Plant	93.89	7.76	12.10
Gain for H 109		+7.61	+0.10	+1.15

H 471. A test at Ewa with H 109 yielded:

Variety	Crop	Cane	Q. R.	Sugar
H 109	Plant	146.97	8.31	17.69
H 471	Plant	92.80	8.14	11.40
Gain for H 109		+54.17	—0.17	+6.29

H 472. A test at Ewa comparing H 472 with H 109 gave:

Variety	Crop	Cane	Q. R.	Sugar
H 109	Plant	145.39	8.67	16.77
H 472	Plant	87.39	8.28	10.55
		58.00	—0.39	6.22

Maui—

H 456. Pioneer Mill Company—No harvesting data.
H 463. Pioneer Mill Company—No harvesting data.
H 471. Pioneer Mill Company—No harvesting data.
H 472. Pioneer Mill Company—No harvesting data.

Hawaii—

H 456. Pahala—No harvesting data—good growth.
Olaa—No harvesting data—good growth.
Waiakea—No harvesting data—good growth.
Onomea—No harvesting data—good growth.

Honomu—No harvesting data—good growth.

Hakalau reports the following test giving a good gain for H 456 over Yellow Caledonia:

Variety	Crop	Cane	Q. R.	Sugar
H 456	Plant	66.09	7.53	8.78
Yellow Caledonia	Plant	40.91	7.91	5.17
Gain for H 456		+15.18	+0.38	+3.61

H 457. Hakalau has secured good results at a high elevation in cane yield but poor juice from H 457.

Variety	Crop	Cane	Q. R.	Sugar
H 457	Plant	76.22	11.05	6.90
Yellow Caledonia	Plant	58.52	7.91	7.39
Gain for H 457		+17.70	—3.14	—0.49

H 463. Hakalau finds H 463 a promising high land cane in this test:

Variety	Crop	Cane	Q. R.	Sugar
H 463	Plant	71.53	7.90	9.05
Yellow Caledonia	Plant	56.10	7.91	7.09
Gain for H 463		+15.43	+0.01	+1.96

H 468. Pahala (No harvesting data—good growth).
H 469. Onomea (No harvesting data—good growth).
H 471. Onomea (No harvesting data—good growth).
H 472. Pahala (No harvesting data—good growth).
H 472. Onomea (No harvesting data—good growth).

"5900" Series

Kauai—

No seedling of the "5900" series has been reported on from Kauai as being especially promising and none have been spread in 1924.

Oahu—

No large areas have been tried out on Oahu of these seedlings during 1924. Harvesting data at Ewa showed them inferior seedlings to H 109.

H 5978.

Variety	Crop	Cane	Q. R.	Sugar
H 109	Plant	162.59	8.58	18.95
H 5978	Plant	108.76	8.69	12.51
Gain for H 109		+53.83	+0.11	+6.44

H 5986.

H 109....................Plant	149.65	9.55	15.67
H 5986...................Plant	125.38	9.79	12.81
Gain for H 109	+24.27	+0.24	+2.86

Maui—

H 5946. Pioneer (No harvesting data—promising).
H 5949. Pioneer (No harvesting data—promising).
H 5974. Pioneer (No harvesting data—promising).
H 5978. Pioneer (No harvesting data—promising).

Hawaii—

H 5949. Waiakea (No harvesting data).
H 5953. Honokaa reports test with D 1135.

Variety	Area	Cane	Q. R.	Sugar
H 5953	.01	47.0	6.84	6.87
D 1135	.01	42.0	7.33	5.83
Gain for H 5953		+5.0	+0.49	+1.04

H 5965. Pahala (No harvesting data—good growth).
Waiakea (No harvesting data).

H 5972. Waiakea (No harvesting data).
Honokaa harvested a test of H 5972 with D 1135.

Variety	Area	Cane	Q. R.	Sugar
H 5972	.01	53.9	6.83	7.87
D 1135	.01	42.0	7.33	5.83
Gain for H 5972		+11.9	+0.50	+2.04

H 5973. Honokaa also tested out H 5973 with D 1135, securing 5 tons of cane per acre more.

Variety	Area	Cane	Q. R.	Sugar
H 5973	.01	47.0	7.61	6.22
D 1135	.01	42.0	7.33	5.83
Gain for H 5973		+5.0	—0.28	+0.39

H 5995. Honokaa reports a test on H 5995.

Variety	Area	Cane	Q. R.	Sugar
H 5995	.01	52.2	8.65	6.04
D 1135	.01	42.0	7.33	5.83
Gain for H 5995		+10.2	—1.32	+0.21

Seedlings of 1918 Kauai Propagation

(Raised by R. S. Thurston.)

Kauai—

Makaweli 1. Hawaiian Sugar Co., no harvesting data.
Makaweli 3. Hawaiian Sugar Co., no harvesting data.
McBryde 1. McBryde Sugar Co., no harvesting data.
McBryde 2. McBryde Sugar Co., no harvesting data.

Seedlings of 1917 Oahu Proparation

At Makiki.

(Raised by J. S. B. Pratt, Jr., and Y. Kutsunai.)

Oahu—

O. P. 268. Ewa reports a test:

Variety	Cane	Q. R.	Sugar
H 109	145.35	7.66	18.97
No. 268	126.45	8.77	14.42
Gain for H 109	+18.90	+1.11	+4.55

O. P. 347 (Ewa 800). Ewa reports two tests:

Variety	Cane	Q. R.	Sugar
H 109	168.33	8.88	18.95
Ewa 800	150.10	8.05	18.65
Gain for H 109	+18.24	—.75	+0.30

Variety	Cane
H 109 (Short plant)	63.93
Ewa 800	60.90
Gain for H 109	+3.03

O. P. 394. (Ewa No. 801). Ewa reports a test:

Variety	Cane	Q. R.	Sugar
Ewa 801	116.32	8.25	14.10
H 109	107.60	8.09	13.30
Gain for Ewa 801	+8.72	—0.16	+0.80

Maui—

O. P. 11.	Pioneer, no harvesting data, reports good growth.
60.	Pioneer, no harvesting data, reports good growth.
78.	Pioneer, no harvesting data, reports good growth.
287.	Pioneer, no harvesting data, reports good growth.
347 (Ewa 800).	Pioneer, no harvesting data, reports good growth.
349 (Ewa 801).	Pioneer, no harvesting data, reports good growth.
746.	Pioneer, no harvesting data, reports good growth.

Kauai—

O. P. 229 (Honokaa No. 1). Grove Farm, no harvesting data.

Hawaii—

Honokaa has tested out these seedlings on a small scale and has spread O. P. 1917 229, or Honokaa No. 1, to 15 acres. The yields follow:

Variety	Cane	Q. R.	Sugar
O. P. 11	39.2	6.46	6.06
D 1135	42.8	7.33	5.83
Gain or Loss for O. P. 11	—3.6	+0.87	+0.23
O. P. 124	46.0	7.23	6.36
D 1135	42.8	7.33	5.83
Gain for O. P. 124	+3.2	+0.10	+0.53
O. P. 134	42.8	7.28	5.88
D 1135	42.8	7.33	5.83
Gain for O. P. 134	....	+0.05	+0.05
O. P. 176	39.6	6.68	5.92
D 1135	42.8	7.33	5.83
Gain or Loss for 176	—3.2	—0.65	+0.09
O. P. 229 (Honokaa No. 1)	25.8	8.93	2.77
D 1135	24.7	8.19	3.15
Gain or Loss for 229	+1.1	—0.74	—0.38
O. P. 719	45.8	6.59	6.94
D 1135	42.8	7.33	5.83
Gain or Loss for 719	+3.0	+0.74	+1.11
O. P. 748	42.3	7.20	5.88
D 1135	42.8	7.33	5.83
Gain or Loss for 748	+0.5	+0.13	+0.05

Seedlings of 1917 Maui Propagation

(Raised by J. T. Moir, Jr., at Wailuku.)

Kauai—

Wailuku 2. McBryde, no harvesting data, reports good growth.
Wailuku 2. Koloa, no harvesting data, reports good growth.
Wailuku 4. McBryde, no harvesting data, reports good growth.
Wailuku 9. Koloa, no harvesting data, reports good growth.
Wailuku 10. McBryde, no harvesting data, reports good growth.
Wailuku 11. Koloa, no harvesting data, reports good growth.
Wailuku 13. Koloa, no harvesting data, reports good growth.

Oahu—

Wailuku 2. Kahuku, no harvesting data, reports good growth.

Wailuku 2. Ewa reports harvesting test on 10 months old cane:

Wailuku 2	48.82 cane per acre
H 109	47.36 cane per acre
Gain for W 2	1.46 cane per acre

Wailuku 11. Ewa reports test on 10 months old cane:

H 109	62.85 cane per acre
Wailuku 11	57.03 cane per cane
Gain for H 109	5.82 cane per acre

Wailuku 13. Ewa reports test on 10 months old cane:

Wailuku 13	66.32 cane per acre
H 109	62.85 cane per acre
Gain for W 13	3.47 cane per acre

Maui—

The seedlings have been spread rapidly and except at Wailuku no harvested experiments show how the seedlings rank. The Experiment Station monthly letter of June 7, 1924, gives some comparative yields with H 109 from which the following is taken:

Variety	Cane	Q. R.	Sugar
W 2	109.4	10.71	10.21
H 109	99.9	7.60	13.12
Gain or Loss for W 2	+9.5	—3.11	—2.81
W 4	90.3	8.25	10.94
H 109	102.4	7.60	13.54
Gain or Loss for W 4	—12.1	—0.65	—2.60
W 11	126.1	8.93	14.11
H 109	99.1	7.60	13.02
Gain or Loss for W 11	+27.0	—1.33	+1.09

Herewith follows a list of the Wailuku seedlings being extended to larger areas and considered worth further trial at the places mentioned:

Wailuku 1 —H. C. & S. Co., Wailuku, Pioneer.
Wailuku 2*—H. C. & S. Co., Wailuku, Olowalu, Pioneer.
Wailuku 4*—H. C. & S. Co., Wailuku, Maui Agricultural, Pioneer.
Wailuku 5 —Wailuku.
Wailuku 6 —Wailuku.
Wailuku 9*—Maui Agricultural, Wailuku.
Wailuku 11*—Wailuku, Pioneer.
Wailuku 12 —H. C. & S. Co., Olowalu, Pioneer.
Wailuku 13 —Wailuku.
Wailuku 15 —H. C. & S. Co., Olowalu, Pioneer.
Wailuku 16 —H. C. & S. Co.
Wailuku 17 —Pioneer.
Wailuku 21*—Pioneer.
Wailuku 23*—Pioneer.
Wailuku 26 —H. C. & S. Co.
Wailuku 42*—Pioneer.
Wailuku 47 —H. C. & S. Co.
Wailuku 49*—H. C. & S. Co., Wailuku, Pioneer.
Wailuku 50*—H. C. & S. Co., Wailuku, Olowalu, Pioneer.
Wailuku 51*—Wailuku, Pioneer.
Wailuku 54 —Maui Agricultural.
Wailuku 55*—H. C. & S. Co., Pioneer.
Wailuku 56 —H. C. & S. Co.
Wailuku 57 —Wailuku.
Wailuku 62*—Pioneer.
Wailuku 64*—H. C. & S. Co., Pioneer.
Wailuku 65 —H. C. & S. Co.
Wailuku 66 —H. C. & S. Co.
Wailuku 67 —H. C. & S. Co.
Wailuku 68 —H. C. & S. Co.
Wailuku 69 —H. C. & S. Co.
Wailuku 70 —H. C. & S. Co.
Wailuku 71*—H. C. & S. Co.
Wailuku 72 —H. C. & S. Co.
Wailuku 73*—Wailuku, Pioneer.
Wailuku 74*—H. C. & S. Co.
Wailuku 75*—H. C. & S. Co.

* Including 28, 29, 30, 43, 44, 58 recommended for trial under different environments by Mr. W. W. G. Moir.

Hawaii—

Wailuku 1. Waiakea, no harvesting data.
Wailuku 2. Waiakea, no harvesting data.
Wailuku 2. Onomea no harvesting data.
Wailuku 2. Hilo Sugar, no harvesting data.
Wailuku 4. Waiakea, no harvesting data.
Wailuku 6. Waiakea, no harvesting data.
Wailuku 10. Waiakea, no harvesting data.

Seedlings of 1917 Hawaii Propagation

(Raised by W. P. Alexander at Kohala and Hilo.)

Kauai—

Kohala 117. Grove Farm, no harvesting data.
Kohala 202. Grove Farm, no harvesting data.

Hawaii—

Kohala 4. Kohala Sugar Co., no harvesting data.
Kohala 4. Waiakea Mill, no harvesting data.
Kohala 73. Kohala Sugar Co., no harvesting data.
Kohala 107. Kohala Sugar Co., no harvesting data.
Kohala 107. Waiakea Mill, no harvesting data.
Kohala 115. Kohala Sugar Co., no harvesting data.
Kohala 117. Waiakea Mill, no harvesting data.
Kohala 117. Kohala Sugar Co., no harvesting data.
Kohala 202. Waiakea Mill, no harvesting data.
Kohala 202. Kohala Sugar Co., no harvesting data.
Waiakea 1. Waiakea Mill, no harvesting data.

"8900" Series

H 8901. Pahala (No harvesting data), reports good growth.
H 8906. Pahala (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Waipio (No harvesting data), reports good growth.
Hawaiian Sugar (No harvesting data), reports good growth.
H 8948. Kahuku (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	145.77	8.22	17.73
H 8948	128.52	9.10	14.12
Gain for H 109	+17.25	+0.88	+3.61

H 8954. Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
H 8958. Pahala (No harvesting data), reports good growth.

Waiakea (No harvesting data), reports good growth.
Kahuku (No harvesting data), reports good growth.
Waialua (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Ewa (No harvesting data), reports only fair ratoons.

H 8961. Kahuku (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Waiakea (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.

H 8965. Pahala (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Waialua (No harvesting data), reports good growth.
Waipio (No harvesting data), reports good growth.
Kahuku (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
Hawaiian Sugar (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	145.77	8.22	17.73
H 8965	108.42	8.69	12.48
Gain for H 109	+37.35	+0.49	+5.25

H 8969. Pahala (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.

H 8973. Kahuku (No harvesting data), reports good growth.
Pioneer (No harvesting data),reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Hawaiian Sugar (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	145.77	8.22	17.73
H 8973	113.03	9.67	11.69
Gain for H 109	+32.74	+1.45	+6.04

H 8978. Kahuku (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Hawaiian Sugar (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	145.77	8.22	17.73
H 8978	130.23	9.66	13.32
Gain for H 109	+15.54	+1.44	+4.41

H 8982. Waiakea (No harvesting data), reports good growth.
H 8984. Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
H 8988. Oahu Sugar (No harvesting data), reports good growth.
Pioneer (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
Ewa (No harvesting data), reports good growth.
H 8993. Pahala (No harvesting data), reports good growth.
Oahu Sugar (No harvesting data), reports good growth.
Kahuku (No harvesting data), reports good growth.
Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	145.77	8.22	17.73
H 8993	91.98	8.89	10.35
Gain for H 109	+53.79	+0.67	+7.38

H 8994. Pioneer (No harvesting data), reports good growth.
Kahuku (No harvesting data), reports good growth.
Waialua (No harvesting data), reports good growth.
Waipio (No harvesting data), reports good growth.
Hawaiian Sugar (No harvesting data), reports good growth.
Koloa (No harvesting data), reports good growth.
H 89102. Maui Agricultural (No harvesting data), reports good growth.
Hawaiian Commercial & Sug. Co. (No harvesting data), reports good growth.
Ewa reports following test:

Variety	Cane	Q. R.	Sugar
H 109	159.29	8.10	19.67
H 89102	116.69	8.69	13.43
Gain for H 109	+42.60	+0.59	+6.24

H 89164. Ewa (No harvesting data), reports good growth.
H 89205. Ewa (No harvesting data), reports good growth.
H 89258. Ewa (No harvesting data), reports good growth.
H 89282. Ewa (No harvesting data), reports good growth.

1918 Seedlings Selected by Dr. Lyon

H 8139. Pioneer, no harvesting data, reports good growth.
H 86441. Pioneer, no harvesting data, reports good growth.
H 86441. Ewa, no harvesting data, reports good growth.
H 86465. Ewa, no harvesting data, reports good growth.
H 86465. Pahala, no harvesting data, reports good growth.
H 86484. Ewa, no harvesting data, reports good growth.
H 86484. Pahala, no harvesting data, reports good growth.

Ewa Seedlings—

Harvesting data on three of the Ewa seedlings propagated in 1915-16 gave the following yields:

Variety	Cane	Q. R.	Sugar
H 109	147.64	9.39	15.72
Ewa 371	132.71	9.18	14.46
Gain for H 109	+14.93	—0.21	+1.26
H 109	112.66	8.04	13.41
Ewa 383	107.85	8.42	13.38
Gain for H 109	+4.81	+0.38	+0.03
H 109	158.09	10.41	15.19
Ewa 387	123.64	8.82	14.02
Gain for H 109	+34.45	—1.59	+1.17

1919—1920 H. S. P. A. Seedlings—

Seedlings of the 1919 and 1920 propagations are just beginning to be spread to large enough areas so that estimates can be made of their worth.

Uba Hybrid No. 1 is being watched with interest.

H 9923 is attracting attention on account of its rapid growth.

The Badila seedlings are below standard.

Sugar Losses in Cane Damaged by Rats and Beetle Borer*

By Raymond Elliott.

The brown rat (Rattus norvegicus), and cane borer (Rhabdocnemis obscura, Boisd.) are the two major pests of cane in the Hamakua district. The damage done amounts to thousands of dollars annually.

The rat is being somewhat controlled by artificial methods, i. e., poisons, traps, etc. The cane borer has its natural enemy, the Tachinid fly (Ceremasia sphenophari).

Mr. Pemberton, of the H. S. P. A. Experiment Station, has been examining borer-injured cane to determine the efficiency of the borer parasite at Paauhau. His results on that particular phase of control will be published later.

The object of the writer, in conducting the following experiments, is to show in dollars and cents just what this loss amounts to.

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924

There were fifty experiments, twenty-six rat-eaten cane and twenty-four cane borer injury, harvested over a period of four months (February to May, 1924, inclusive), from five irrigated fields. Each experiment represents approximately ten acres.

Thirty feet of a cane row were taken at different parts of the field. The row was stripped, it was then cut and the stalks counted. Each stick was examined for damage done by the cane borer or rat, depending upon whether it was a rat or cane borer experiment, and tabulated accordingly.

The cane was then brought to the mill, weighed and divided into two separate piles and labeled piles Nos. 1 and 2. Pile No. 1 was then divided into seven equal parts and analyses made. This bundle will serve as a control over that part which is actually infested by the borer or damaged by the rat.

In pile No. 2, all sound cane and damaged cane were segregated. The sound cane was weighed and divided into seven equal parts, analyzed and designated as 2A.

The damaged cane is gone over very thoroughly and that part which is damaged is cut out. If the stalk still shows a red discoloration and gives off a sour odor it is still cut away until the discolored parts and odor disappear. The sound parts are weighed, analyzed and designated as 2B.

The damaged part is weighed, analyzed and designated as 2C.

A summary of the results is as follows:

TABLE I.

CANE BORER DAMAGE

No. of Experiments	Variety	Per cent Sticks With Cane Borer
3	H 20	55.56
11	Y. C.	30.54
3	D 1135 and Y. C.	22.58
2	H 109	21.43
5	D 1135	11.32
—		———
24		True Average....27.17

RAT DAMAGE

No. of Experiments	Variety	Per cent Sticks
2	H 20	50.24
6	D 1135	36.07
16	Y. C.	29.07
1	H 109	23.77
1	D 1135 and Y. C.	22.58
—		———
26		True Average....32.92

The analyses of the cane borer and rat-eaten cane experiments follow:

TABLE II.

	Bundle No. 1								Bundle No. 2							
	1				2A				2B				2C			
	Control (sound and unsound cane)				Sound Cane				Sound Cane after damaged parts had been cut out				Damaged parts			
True Averages	Brix	Pol'n	Pur.	Q. R.	Brix	Pol'n	Pur.	Q. R.	Brix	Pol'n	Pur.	Q. R.	Brix	Pol'n	Pur.	Q. R.
Cane Borer Experiments	18.82	16.79	89.21	7.90	19.35	17.44	90.13	7.55	19.08	16.97	88.94	7.83	14.01	9.83	70.16	16.67
Rat-Eaten Cane Exps....	18.28	16.15	88.35	8.27	18.87	16.71	88.55	7.98	17.92	15.77	88.00	8.49	13.14	9.13	69.48	18.15

N. B. Wt. of Bundle 1, Wt. of Bundle 2 = Total Wt. Wts. 2A, 2C = Wt. Bundle 2.

The figures that we are most interested in are those of 2A and 2C. If the cane was all damaged as in 2C it would take the above amounts, as indicated, to make a ton of sugar. However, when the weights are really known, it is much larger than a person would expect. The actual weights of damaged cane are 7.47 lbs., 7.81 lbs. per 100 lbs. of cane by the rat and cane borer respectively.

Taking the stalks and cutting out that portion which is damaged, we have 30.83 and 31.78 lbs. per 100 lbs. of cane respectively.

Table III.

Per cent Rat Eaten Cane and Losses Calculated to Dollars and Cents, Taking Sugar at $0.07 per lb.

RAT-EATEN CANE LOSSES

	F. 2	F. 9	F. 15½	F. 14A	F. 7	True Ave.
Per cent total sticks rat eaten	10.42	14.51	36.07	48.21	54.00	32.92
Per cent loss in sugar per acre	1.305	1.357	4.366	6.594	16.430	5.861
Loss in dollars and cents per acre	9.912	14.028	43.400	61.810	135.128	51.884
Loss in dollars and cents per 1 per cent rat-eaten cane per acre	.951	.967	1.203	1.282	2.502	1.576

Table IV.

Per cent Infestation and Losses Calculated to Dollars and Cents, Taking Sugar at $0.07 per lb.

CANE BORER LOSSES

	F. 15½	F. 9	F. 2	F. 14A	F. 7	True Ave.
Per cent total sticks with cane borer	8.43	18.72	24.30	29.88	53.13	27.17
Per cent loss in sugar per acre	.394	1.460	.737	3.193	15.212	4.581
Loss in dollars and cents per acre	1.876	13.622	5.950	31.038	157.822	42.308
Loss in dollars and cents per 1 per cent infestation per acre	.223	.728	.245	1.038	2.970	1.557

Discussion of Results.

Table I, the number of stalks damaged, expressed as a percentage, shows that the variety H 20 is the most susceptible to damage by both enemies. The areas planted to H 20 at Paauhau are very small and are more in the nature of an experiment in the different fields. The number of experiments harvested are given opposite each variety and are self-explanatory.

Turning to the figures in Table II, the reader should bear in mind that the figures as given in 2A are the quality ratios of sound cane that is not damaged by either of the two above-mentioned pests; while in 2B are the stalks after having the damaged part cut out; 2C is that part that is actually damaged and is one of the factors for requiring more cane to make a ton of sugar, and incidentally giving a juice of somewhat lower purity.

The difference in quality ratios of 1 and 2A are indicative of the amounts to make a ton of sugar where you have damaged cane mixed with the sound cane and sound cane alone.

In Tables III and IV are given the percentages and losses by the rat and cane borer, field by field, with a true average summary.

In 1923, the writer did not conduct any experiments re the damage done by rats, experiments being confined to that of the cane borer.

The percentage of stalks with cane borer in 1923 approximates that of 1924 very closely, namely, 26.48 as against 27.17.

If we exclude the experiments of F7, the loss in dollars and cents for the cane borer and rat-eaten experiments are $0.56 and $1.10 per acre per one per cent infestation respectively.

The loss in the 1923 experiments for cane borer was $0.655 per one per cent of infestation per acre.

It should be noted that in the experiments on rat-eaten cane the greater the per cent stalks of cane damaged, the greater the loss in dollars and cents per one per cent rat-eaten cane per acre.

In the cane borer experiments, that is in most but not all cases, the greater the borer infestation, the greater the losses per one per cent infestation per acre.

Annual Synopsis of Mill Data, 1924

By W. R. McAllep

Data in this Synopsis, represent all sugar produced by plantations in the Association from September 30, 1923, to September 30, 1924. Data are included for portions of the 1923 crop of three factories that had not finished grinding on the former date. Five factories had not finished grinding in time to submit figures for all of the 1924 crop. The unfinished portions will be included in the next Synopsis. Figures including unfinished portions of the 1923, and figures that do not represent the whole of the 1924 crop are so designated in the first of the large tables.

The form in which data are presented is much the same as in the last few seasons. A number of tables give detailed information on quality of cane, milling, boiling house work, etc. Operating data and averages for the last ten years are in the first of the three large tables. The second large table contains mill settlings, etc., and the third, surface and juice grooving. When not otherwise noted, factories are listed according to the average size of the crop for the preceding five seasons.

Attention was called in last year's Synopsis to peculiarities in control figures for the Petree process. Many of these figures are not directly comparable with corresponding data for factories that do not return settlings to the mill. Averages for the total crop as compiled in these Synopses are materially affected in some particulars. The writer would refer to last year's Synopsis for further details. A third factory has now installed this process and the other two have had proportionately larger crops, increasing the percentage of sugar produced by this process from 12 per cent in 1923 to slightly under 16 per cent this year. Last year averages were influenced by these figures to the extent that valid comparisons with the work of previous years, on the basis of true averages for all the factories, were rendered difficult and uncertain. This year the difficulty is accentuated.

Data as compiled in these Synopses serve a useful purpose in classifying factories according to the quality of the work. In the writer's opinion, however, comparisons of one season's work with another on the basis of averages for the entire crop, particularly when supplemented with analyses of results at individual factories serve a much more useful purpose. In several respects these comparisons afford more definite and reliable information than can be obtained in any other way. They show to what extent results indicated by experimental work are secured in practice. They reflect the effect of changes in conditions and operating methods and show in true perspective the general trend of factory operations. The difficulty in making close, valid comparisons with previous seasons in extraction, recovery and other averages affected by the Petree process, detracts materially from the value of these Synopses.

Table 3 containing averages for the last three years for all factories that do not now use the Petree process, overcomes the difficulty for these three seasons. By taking into consideration differences between 1922 averages in Table 3 and corresponding 1922 averages for all factories, somewhat better comparisons can be made with the work of years previous to 1922 than can be made on the basis of averages in the large table, but the comparisons are still unsatisfactory.

TABLE NO. 1

VARIETIES OF CANE

	H 109	Y. C.	D 1135	Lahaina	Striped Mexican	Yellow Tip	Striped Tip	Rose Bamboo	Other Varieties
H. C. & S. Co.	77	..	15	7	1	..	..	..	..
Oahu	70	..	15	5	..	..	..	..	10
Ewa	100	..	..	..	..	..	..	..	..
Waialua	37	10	25	7	..	..	..	..	21
Pioneer	58	..	3	4	31	..	..	..	4
Olaa	..	87	13	..	..	..	..	..	..
Haw. Sug.	53	1	32	..	..	..	..	..	14
Maui Agr.	61	2	1	14	9	..	..	13	..
Onomea	..	78	..	..	..	22	..	..	..
Lihue	18	79	1	..	..	..	..	..	2
Haw. Agr.	..	53	10	..	4	..	..	..	33
Hakalau	..	93	..	..	..	7	..	..	..
Honolulu	75	19	5	1	..	..	..	..	..
Kekaha	19	..	16	62	..	..	..	..	3
Hilo	..	95	5	..	..	..	..	..	..
Wailuku	62	1	2	15	20	..	..	..	..
McBryde	54	36	10	..	..	..	..	..	..
Makee	20	78	..	..	..	..	..	..	2
Honokaa	7	19	73	..	..	..	..	..	1
Laupahoehoe	..	42	12	..	..	42	3	..	1
Pepeekeo	..	93	1	..	..	6	..	..	..
Hamakua	..	34	50	..	..	3	1	..	12*
Kahuku	49	46	..	5	..	..	..	..	..
Paauhau	6	42	45	..	..	6	..	..	1
Honomu	..	99	..	..	..	..	..	..	1
Koloa	14	77	5	..	..	..	..	..	4
Waiakea	..	98	1	..	..	1	..	..	..
Hutchinson	..	39	..	..	..	..	1	59	1
Hawi	28	9	19	..	4	3	37	..	..
Waianae	100	..	..	..	..	..	..	..	..
Kaiwiki	..	48	14	..	..	2	21	..	15*
Kohala	..	22	40	..	..	11	23	..	4
Kilauea	8	59	2	..	..	..	..	..	31†
Kaeleku	..	100	..	..	..	..	..	..	..
Waimanalo	76	23	1	..	..	..	..	..	..
Halawa	..	40	15	..	..	..	45	..	..
Union Mill	..	14	8	..	..	..	77	..	1
Waimea	40	1	2	56	..	..	..	..	1
Olowalu	73	..	..	5	22	..	..	..	..
Niulii	..	55	14	..	..	15	16	..	..
True Average 1924	38.1	32.6	12.0	4.4	2.5	2.3	2.0	1.4	4.7
" " 1923	30.7	36.3	11.2	8.4	3.1	1.2	1.6	1.5	6.0
" " 1922	21.1	40.3	12.2	12.0	2.8	2.7	1.6	1.6	5.7
" " 1921	15.0	45.1	11.0	17.4	3.0	1.2	1.8	1.0	4.5
" " 1920	9.1	42.7	10.0	26.7	2.5	1.4	2.1	0.8	4.7
" " 1919	6.8	46.4	7.2	29.1	1.8	0.3	2.6	2.1	3.7
" " 1918	4.0	42.9	7.5	37.9	0.6	0.5	1.5	1.1	4.0

* Principally D 117.

† Principally Badila

TABLE NO. 2

COMPOSITION OF CANE BY ISLANDS

	Hawaii	Maui	Oahu	Kauai	Whole Group
1915					
Polarization	12.61	15.23	14.29	14.09	13.77
Percent Fiber	13.00	11.44	12.77	12.46	12.51
Purity 1st Expressed Juice	87.86	90.48	87.27	86.99	88.24
Quality Ratio	.....	.....	.....	.....	8.03
1916					
Polarization	12.54	14.62	13.74	13.26	13.45
Percent Fiber	13.22	12.22	12.51	12.86	12.74
Purity 1st Expressed Juice	87.56	89.41	87.15	86.26	87.70
Quality Ratio	.....	.....	.....	.....	8.22
1917					
Polarization	13.31	15.43	13.55	13.13	13.76
Percent Fiber	13.23	11.67	12.25	12.89	12.62
Purity 1st Expressed Juice	88.11	90.40	86.77	86.70	88.02
Quality Ratio	8.21	7.03	8.20	8.27	7.95
1918					
Polarization	11.88	14.25	13.50	12.54	12.97
Percent Fiber	13.35	11.53	12.23	12.84	12.50
Purity 1st Expressed Juice	87.27	88.62	86.93	85.88	87.18
Quality Ratio	9.27	7.73	8.27	8.60	8.47
1919					
Polarization	12.74	15.12	14.24	13.52	13.74
Percent Fiber	13.07	11.74	12.14	12.61	12.49
Purity 1st Expressed Juice	87.54	88.81	87.00	85.82	87.34
Quality Ratio	8.66	7.25	7.81	8.20	8.05
1920					
Polarization	12.86	15.29	13.75	13.07	13.64
Percent Fiber	13.36	11.39	12.65	12.72	12.64
Purity 1st Expressed Juice	87.87	88.94	85.40	86.52	87.24
Quality Ratio	8.45	7.08	8.07	8.28	8.00
1921					
Polarization	12.25	14.67	13.72	12.67	13.12
Percent Fiber	13.28	11.82	12.40	13.28	12.80
Purity 1st Expressed Juice	87.18	87.37	85.46	84.07	86.22
Quality Ratio	8.98	7.51	8.11	8.76	8.41
1922					
Polarization	12.07	13.95	13.61	13.03	12.97
Percent Fiber	13.16	12.38	12.88	13.22	12.95
Purity 1st Expressed Juice	87.17	87.88	86.18	85.80	86.84
Quality Ratio	9.19	7.75	8.04	8.36	8.45
1923					
Polarization	12.09	13.61	12.99	12.94	12.78
Percent Fiber	13.14	12.01	12.86	12.99	12.82
Purity 1st Expressed Juice	87.61	88.65	85.52	86.58	87.05
Quality Ratio	9.12	7.91	8.50	8.42	8.57
1924					
Polarization	12.44	14.34	13.48	13.34	13.26
Percent Fiber	12.99	12.16	12.72	12.94	12.74
Purity 1st Expressed Juice	87.98	89.19	87.02	87.31	87.86
Quality Ratio	8.86	7.58	8.16	8.12	8.25

Varieties of Cane

Varieties ground to the extent of 1 per cent or more of the total crop are included in Table 1. D 117 no longer appears, as the tonnage of this variety has dropped to less than 1 per cent of the total crop. Yellow and Striped Tip are tabulated in separate columns instead of together as in previous years. This table shows the proportion of the major varieties ground at each factory. Averages for the previous six years are included.

For the first time in many years, Yellow Caledonia has been displaced as the leading variety in tonnage ground. The proportion of H 109 exceeds Yellow Caledonia this year to approximately the same extent that Caledonia exceeded H 109 in 1923. The proportion of Lahaina is but little more than a half of what it was a year ago. This once important variety now amounts to but 4.4 per cent of the crop. It is interesting to note that the proportions of H 109 and Lahaina in 1918 and 1924 are almost exactly reversed. Taking into consideration the biennial nature of the crop, D 1135 and Striped Mexican are about holding their own. The proportion of the Tip canes is the same as in 1922. The proportion of Rose Bamboo has been steadily decreasing during the last three years.

Minor varieties making up 1 per cent or more of the crop of any one plantation were ground to the following extent:

Variety	Per Cent of Total Crop
H 146	.51
D 117	.49
Badila	.46
White Bamboo	.11
Uba	.03
Yellow Bamboo	.02
Total	1.62

H 227 and H 20 were in this classification last year. None of the former was reported this season. H 20 was ground to a slightly greater extent than Uba but did not make up 1 per cent of the crop at any plantation. Of the varieties listed above, H 146, D 117 and Yellow Bamboo have decreased considerably in comparison with last year. Badila has increased materially, the proportion last year being only .13 per cent. Uba appears in this classification for the first time.

Quality of Cane

Table 2 contains data on quality of cane by Islands and for the whole group for the past ten years. Quality ratios have been included this year to facilitate comparisons.

Last year the quality of the cane had improved slightly over that of the two previous seasons. This year a material further improvement has taken place. The quality ratio has decreased from 8.57 to 8.25. On Oahu the quality is the best since 1922, on Maui since 1921, on Hawaii since 1920 and on Kauai since 1919. The average quality is better than in any year since 1920. As is usually

TABLE NO. 3.

True Averages of All Factories Except Those Now Using the Petree Process.

	1922	1923	1924
Cane—			
Polarization	12.77	12.66	13.08
Fiber	13.03	12.91	12.82
Tons per ton sugar	8.76	8.68	8.40
Bagasse—			
Polarization	1.71	1.53	1.52
Moisture	41.31	41.29	41.26
Fiber	56.23	56.48	56.74
Polarization per cent cane	0.40	0.35	0.34
Polarization per cent polarization of cane	3.11	2.76	2.63
Milling loss	3.05	2.71	2.68
Weight per cent cane	23.16	22.84	22.59
First Expressed Juice—			
Brix	18.23	17.99	18.34
Polarization	15.79	15.61	16.07
Purity	86.58	86.77	87.61
"Java ratio"	80.9	81.1	81.4
Mixed Juice—			
Brix	13.26	13.11	13.37
Polarization	11.07	11.00	11.31
Purity	83.50	83.87	84.56
Weight per cent cane	111.65	111.95	112.66
Polarization per cent cane	12.38	12.31	12.74
Extraction	96.89	97.24	97.37
Extraction ratio	0.24	0.21	0.21
Last Expressed Juice—			
Polarization	1.96	1.73	1.84
Purity	68.66	68.48	71.73
Maceration per cent cane	34.99	34.79	35.30
Syrup—			
Brix	63.11	63.33	63.18
Purity	84.81	85.40	86.02
Increase in purity	1.31	1.53	1.46
Press Cake—			
Polarization	1.96	2.20	2.16
Weight per cent cane	2.49	2.45	2.45
Polarization per cent cane	0.05	0.05	0.05
Polarization per cent polarization of cane	0.38	0.43	0.40
Lime used per cent cane	0.081	0.085	0.086
Commercial Sugar—			
Polarization	96.88	96.88	97.20
Moisture	0.85	0.80	0.73
Weight per cent cane	11.41	11.53	11.91
Polarization per cent cane	11.06	11.17	11.58
Polarization per cent polarization of cane	86.94	88.37	88.76
Polarization per cent polarization of juice	89.69	90.86	91.16
Final Molasses—			
Weight per cent cane	3.14	2.96	2.83
Sucrose per cent cane	1.07	0.99	0.97
Sucrose per cent polarization of cane	8.33	7.79	7.45
Sucrose per cent polarization of juice	8.60	8.01	7.65
Gravity solids	87.94	88.54	89.08
Gravity purity	38.60	37.68	37.81
Undetermined Losses—			
Polarization per cent cane	0.21	0.11	0.14
Polarization per cent polarization of cane	1.28	0.65	0.76

the case, the cane is best on Maui and poorest on Hawaii. It is of practically the same quality on Oahu and Kauai, a slight difference of .04 in quality ratio being in favor of Kauai.

A most satisfactory development is improvement in juice purity. The average purity of the first expressed juice is better than in any year since 1917. This is also true of Maui and Hawaii. On Oahu the purity is better than in any year since 1916, while on Kauai it is necessary to go back to 1914 to find better first expressed juice purity. On the basis of first expressed juice purity, the Islands rank as follows: Maui, Hawaii, Kauai and Oahu.

The average fiber is lower than in the preceding three seasons. For a number of years there has been a consistent tendency toward lower fiber on Hawaii. The figure reported this year is lower than in any year since 1910. On Maui the tendency is toward higher fiber. With the exception of 1922, the fiber reported from Maui is the highest on record. On Oahu the fiber was lower than in the preceding two seasons and on Kauai, lower than in the preceding three.

Milling

An interesting feature of the milling work this year is the increased grinding rate. Average grinding rates for the last five years are in the following tabulation. This figure is the total tons of cane ground divided by the total hours grinding. Average tons pressure per linear foot of roller for the last three years are also included. Two-roller crushers have not been included in the calculation:

	Tons Cane per Hour	Tons Pressure per Linear Foot of Roller
1920	39.34	. . .
1921	36.58	. . .
1922	39.93	65.2
1923	42.03	66.2
1924	43.63	66.9

Grinding rates have increased each year since 1921, the total increase amounting to 19 per cent. The increase over last year is 1.6 tons per hour. The increase has been quite general, but three factories reporting decreases of one ton or more per hour. Pressure per foot of roller has also steadily increased in the years for which figures are available.

Water added per cent cane has decreased from 35.12 to 34.90. The water actually applied per hour has increased slightly (3 per cent), due to the increased grinding rate. With the single exception of 1922, water added per cent cane has been lower than in any year since 1914. At factories that do not use the Petree process, maceration increased from 34.79 to 35.3 per cent.

Comparison of averages for all factories with corresponding 1923 figures discloses the following: Milling loss, or parts of sugar lost in bagasse per hundred parts of fiber in bagasse has increased from 2.76 to 2.78, while extraction ratio, or the ratio of per cent unextracted sucrose to fiber in cane, has decreased from .22 to .21. Bagasse increased .01 in polarization and .02 in moisture. With

higher polarization and moisture, lower fiber in bagasse might be expected. On the contrary the fiber has increased .01. This is due to an increase in residual juice purity, that is, a reduction in the soluble impurities in the juice remaining in the bagasse. Taking all these factors into consideration, the quality of the milling work very closely approximates that of last season, notwithstanding the higher grinding rate and decreased maceration.

Due to higher polarization and lower fiber in cane, the extraction is .10 higher than last year. Figures for the Petree process have increased the average figure by possibly .03 above what it should be. Deducting this from the average gives a figure identical with that of 1919, between .10 and .15 lower than in 1920 and 1921, and higher than in other years.

At factories that are not using the Petree process (Table 3), in comparison with last year, bagasse polarization has decreased 0.01 and bagasse moisture .03, while bagasse fiber has increased .26. Milling loss has decreased .03. Extraction ratio has decreased from .214 to .205, though the decrease is not apparent in the table where the figures are carried to two decimal places only. Extraction has increased .13. At these factories the milling work is better than in 1923 or 1922. As previously pointed out comparisons with years previous to 1922 are unsatisfactory, but as nearly as the figures can be interpreted, milling work at these factories is as good as in any previous season. It is quite probable that except for the Petree process, milling work as a whole would have been equal to that of any previous year, notwithstanding the increased grinding rate.

The difference in purity between first expressed juice and mixed juice, as shown by figures in Table 3, has increased from 2.90 to 3.05. While a number of factors can influence this difference, the amount of field trash and deterioration in the mill are probably the most important. So far as this difference can be accepted as an indication of the amount of field trash and deterioration the indications are that conditions with respect to one or both of these factors have been less favorable than last year. A peculiarity of the data this year is that although the purity difference between first expressed and mixed juice purity is greater than last year the difference between first expressed and last expressed juice purity has decreased from 18.74 to 16.24.

No factory has quite equalled the previous record of 1.09 in milling loss established by Onomea and Hakalau last year, nor has any factory equalled the record for extraction (99.07) established by Hawaiian Commercial and Sugar Company in 1921. Waimanalo has equalled the previous low mark in extraction ratio made by Hawaiian Commercial and Sugar Company in 1921.

The principal changes in milling machinery have been: increasing the milling plant at Kekaha to a fifteen-roller mill and crusher by installing two three-roller units, and installing a three-roller in place of a two-roller crusher at Honomu. The three-roller crusher and nine-roller mill at Waimanalo may be considered a new installation so far as Synopsis figures are concerned, for though operated for two seasons, the previous year's figures were not in the Synopsis.

Reference to Table 4 in which the factories are listed in the order of the size of the milling loss shows that improved work has been secured from these installations. Waimanalo is in second place with 98.87 extraction and 1.12 milling loss. Milling data have not been reported previously from this factory, but un-

doubtedly it was close to, if not at the foot of the list. Kekaha has advanced from thirty-fourth place last year to fifth this year with 1.72 milling loss and 98.48 extraction. Honomu has advanced from seventeenth to sixth place with 1.77 milling loss and 98.27 extraction.

Seven factories report milling losses under 2.0 against five in 1923 and four in 1922. Nine report over 98.0 extraction against five in each of the two preceding years. This equals the previous record for number of factories under 2.0 in milling loss made in 1920. The same number of factories (9), reported better than 98.0 extraction both in 1920 and 1921.

On the basis of milling loss Onomea is first, with Waimanalo second, and Hakalau third. There is little difference between these three leading factories, the figures for milling loss being respectively 1.11, 1.12 and 1.14. Indeed, which of the three is in first place depends on whether milling loss, extraction ratio or extraction is the basis of comparison.

Comparisons of Table 4 with corresponding tables in the previous Synopsis show many changes in relative rank. In addition to the previously mentioned improvements in relative standing due to the installation of new machinery, the following factories have improved their standing to the extent of 5 points or more: Honolulu (33-23), McBryde (25-18), Kahuku (22-16), Ewa (18-13) and Wailuku (13-8). Factories that have dropped in relative rank to the extent of 5 points or more are: Waimea (15-28), Maui Agricultural (19-31), Oahu (10-21), Waialua (21-30), Lihue (7-14), Makee (8-15), Kilauea (12-19), Hamakua (6-12), Hawaiian Agricultural (14-20), Waiakea (31-37) and Laupahoehoe (24-29).

The fact that three of the first nine mills in Table 4 are three-roller crushers and nine-roller mills, while one is in second place, draws attention to the efficient work secured from modern three-roller crushers. An extraction of 75 per cent of the total juice is not particularly high for a three-roller crusher working under reasonably favorable conditions, while securing 50 per cent of the total juice is excellent work with two-roller equipment. Eight installations are classed in this Synopsis as three-roller crushers. Two of these are not properly grooved and can hardly be considered modern three-roller crushers. At a third installation, Petree process settlings are returned to the mill. The remaining five three-roller crusher installations are all in the first half of Table 4. In each case the three-roller crusher is a material factor in the results secured. There is little doubt that comparisons of two and three-roller crushers, taking into consideration fixed charges, operating expenses and the results secured, are considerably in favor of the three-roller type. There are a number of factories without a crusher where substituting properly grooved crusher rollers for the rollers now in the first mill, would bring about a material improvement in the work.

It might also be noted that the Waimanalo factory is equipped with Meinecke chutes. The excellent milling work at this factory should dispose of any doubts that may have existed as to the possibility of securing excellent results with this type of intermediate conveyor.

TABLE NO. 4—MILLING RESULTS.

Showing the Rank of the Factories on the Basis of Milling Loss.

Factory	Milling Loss	Extraction Ratio	Extraction	Equipment
1. Onomea	1.11	0.09	98.89	2RC60,S54,12RM66
2. Waimanalo	1.12	0.08	98.87	K,3RC54,9RM54
3. Hakalau	1.14	0.09	98.90	2RC60,12RM9-60,3-66
4. Hilo	1.22	0.10	98.60	K,2RC60,12RM66
5. Kekaha	1.72	0.12	98.48	2RC54,15RM60
6. Honomu	1.77	0.14	98.27	3RC60,9RM60
7. Pepeekeo	1.84	0.15	98.21	2RC54,9RM60
8. Wailuku	2.04	0.15	98.07	K,2RC72,12RM78
9. Olowalu	2.05	0.16	97.99	K,3RC48,9RM48
10. Paauhau	2.27	0.19	97.51	2RC60,12RM66
11. Pioneer	2.32	0.16	98.06	K,2RC72,S72,15RM72
12. Hamakua	2.32	0.19	97.36	K,2RC60,12RM60
13. Ewa	2.36	0.18	97.73	K(2),2RC78,18RM78
14. Lihue	2.36	0.19	97.62	K,2RC78,S72,12RM78
15. Makee	2.56	0.21	97.16	2RC72,S72,9RM72
16. Kahuku	2.65	0.21	96.63	2RC60,S54,9RM72
17. Haw. Sug.	2.69	0.18	97.81	K,2RC72,S72,12RM78
18. McBryde	2.81	0.20	97.11	K,2RC72,S72,9RM84
19. Kilauea	2.82	0.23	96.77	K,S,3RC60,9RM60
20. Haw. Agr.	2.88	0.24	96.86	3RC60,12RM66
21. Oahu	2.89	0.20	97.51	K(2),2RC78(2),S72(2),12RM78(2)
22. Koloa	2.98	0.23	96.83	K,2RC60,12RM66
23. Honolulu	3.07	0.22	97.45	K(2),S54,2RC78,9RM78
24. Hutchinson	3.07	0.26	96.88	2RC60,9RM60
25. Waianae	3.10	0.23	96.88	K(2),12RM60
26. Olaa	3.16	0.24	96.89	K,S72,12RM78
27. Honokaa	3.18	0.28	96.49	K(2),2RC66,12RM66
28. Waimea	3.26	0.24	97.07	2RC48,12RM42
29. Laupahoehoe	3.27	0.25	96.72	K,2RC60,9RM60
30. Waialua	3.36	0.25	96.71	K(2),2RC78,12RM78
31. Maui Agr.	3.41	0.23	97.33	K(2),3RC66,18RM66
32. Kaiwiki	3.44	0.27	96.35	K,2RC60,9RM60
33. Kohala	3.55	0.28	96.39	K(2),3RC60,9RM60
34. H. C. & S. Co.	3.72	0.26	96.92	K(4),2RC78(2),S72(2),12RM78(2)
35. Kaeleku	4.15	0.35	95.04	K,2RC54,9RM60
36. Hawi	4.34	0.32	95.90	K(2),3RC48,12RM3-48,9-54
37. Waiakea	4.34	0.33	95.27	K,2RC60,9RM60
38. Halawa	5.77	0.48	93.35	K,2RC60,6RM50
39. Union Mill	6.59	0.52	92.87	K,9RM60
40. Niulii	7.53	0.63	91.37	K,9RM54

Extra Fuel

Available data are not sufficiently complete to attempt an at all complete analysis of figures for extra fuel. Fifteen factories, the same number as last year, report the use of extra fuel in greater amounts than should be required for starting up or be occasioned by unexpected delays.

Two factories, Pioneer and Hawaiian Commercial and Sugar Company, accumulated large surpluses of bagasse. The latter, a Petree process factory, accumulated a very large surplus. Maui Agricultural Company, another Petree process factory, made a large reduction in the amount of extra fuel burned in comparison with last year. Waialua and Oahu also report material reductions in the extra fuel requirement.

The writer would repeat the comment made in previous Synopses: that under Hawaiian conditions, with a sufficient supply of cane to grind at a reasonable capacity and with suitable equipment and proper operation, the bagasse, particularly when supplemented with molasses, should furnish sufficient fuel to maintain a high quality of work. Frequently material improvements in fuel conditions can be secured through comparatively minor changes in equipment and operating practice. In some cases however, installations are faulty to the extent that a satisfactory solution of the fuel problem is an extensive undertaking.

Chemical Control and Sucrose Balances

The number of factories reporting the more reliable sucrose figures has increased fairly consistently from year to year. Twenty-five factories have reported sucrose figures, an increase of two over last year. One consideration rendering sucrose figures particularly desirable is the more accurate figure for undetermined loss. On a polarization basis this is from .5 to 1.0 per cent lower than it should be; a factor frequently lost sight of when considering operating data.

Gravity solids and sucrose balances for factories reporting sucrose figures are in Table 5. Where suspended solids in mixed juice has not been reported, it has been estimated at .25 per cent in calculating these balances.

Apparent boiling house recoveries are in Table 6. These are based on polarization. It is necessary in making the calculations to estimate gravity purities from the apparent purities. The factors indicated in the footnote accompanying the table, which are approximately the average differences between apparent and gravity purities for factories reporting both, are used for this purpose. Plus or minus one per cent in the figure for recovery on available covers the probable error due to estimating gravity purities in this way. True boiling house recoveries on a sucrose basis, for factories reporting necessary data, are in Table 7. Tables 6 and 7 are to a large extent a check on the accuracy of chemical control, though low figures may also indicate losses in addition to the losses reported in press cake and molasses. These calculations have been very useful for disclosing inaccuracies in estimating the amount of juice entering the boiling house, which were common when the control was based largely on juice measurements. Now that all but four factories weigh the mixed juice, serious errors in estimat-

TABLE NO. 5

GRAVITY SOLIDS AND SUCROSE BALANCES

Factory	Gravity Solids per 100 Gravity Solids in Mixed Juice				Sucrose per 100 Sucrose in Mixed Juice			
	Press Cake	Commercial Sugar	Final Molasses	Undetermined	Press Cake	Commercial Sugar	Final Molasses	Undetermined
H. C. & S. Co.	1.5	83.3	14.8	0.4	0.3	93.0	6.5	0.2
Oahu	3.0	79.0	16.4	1.6	0.2	91.8	7.4	0.6
Ewa	6.5	74.4	16.4	2.7	0.5	90.2	7.1	2.2
Waialua	6.0	74.6	16.0	3.4	0.6	89.9	7.6	1.9
Pioneer	3.0	79.4	15.8	1.8	0.2	91.7	6.7	1.4
Haw. Sug.	4.1	81.3	14.0	0.6	0.9	93.1	5.9	0.1
Maui Agr.	0	82.9	....	17.1	0	92.0	....	8.0
Onomea	6.1	77.3	15.1	1.5	0.1	91.7	6.9	1.3
Haw. Agr.	3.7	77.8	17.2	1.3	0.2	88.6	7.9	3.3
Hakalau	3.4	79.1	15.4	2.1	0.1	92.8	6.6	0.5
Hilo	4.6	76.6	17.0	1.8	0.4	91.4	7.9	0.3
Wailuku	1.9	80.8	15.7	1.6	0.4	91.6	7.0	1.0
McBryde	4.9	77.5	17.2	0.4	0.3	91.0	7.8	0.9
Makee	2.3	75.0	19.5	3.2	0.3	88.8	8.8	2.1
Honokaa	5.6	74.2	18.2	2.0	0.4	90.2	8.5	0.9
Laupahoehoe	4.1	78.4	14.2	3.3	0.1	91.0	6.6	2.3
Pepeekeo	3.2	78.9	14.5	3.4	0.1	92.0	5.9	2.0
Hamakua	0	78.1	20.4	1.5	0	88.5	10.0	1.5
Paauhau	5.5	75.3	18.4	0.8	0.2	90.3	8.3	1.2
Honomu	5.2	77.2	16.5	1.1	0.3	91.9	7.0	0.8
Waiakea	4.1	78.1	16.0	1.8	0.5	90.7	7.7	1.1
Hutchinson	4.7	75.0	17.8	2.5	0.4	89.0	9.1	1.5
Kilauea	4.7	72.2	18.9	4.2	1.0	88.0	8.8	2.2
Waimanalo	6.3	73.6	17.4	2.7	0.8	88.9	8.6	1.7
Union Mill	5.4	76.0	17.4	1.2	1.4	89.2	8.7	0.7

ing the amount of juice entering the boiling house are not frequent. Also with the general improvement in the quality of the laboratory work there is little doubt but that syrup, sugar and molasses purities are more accurately determined than in former years. In the last two or three years there has been a material change in clarification practice, resulting in smaller losses through inversion because of more alkaline juices. With this change, an increased number of factories report over 100 per cent recovery on the calculated available. Among these are factories at which there is reason to believe that juice weights, and syrup, sugar and molasses purities are determined with a high degree of accuracy. Until the last two or three years we have been inclined to accept the calculated available as the maximum obtainable under the given purity conditions, particularly with calculations on a sucrose basis. Critical examination of our control methods indicates the following small discrepancies:

1. Solids in the sugar are determined by drying. This gives total solids. The purity of the sugar as so determined is slightly higher than the gravity purity.

2. There is a plus error in the method for determining the gravity purity of final molasses due to the lead precipitate, amounting to between .5 and 1.0 per cent. This error has been corrected in the new methods adopted by the Association of Hawaiian Sugar Technologists.

3. Another factor causing a plus error in determining the gravity purity of the molasses is the relative concentration of non-sugars in the solutions in which the brix of the molasses and syrup is determined. Our methods specify approximately the density of the mixed juice for both determinations. At equal densities the non-sugar concentration is higher in the molasses and as a result the gravity solids determination is relatively low. The molasses would have to be analyzed at concentration between 2 and 2.5 Brix for the gravity solids determination to be strictly comparable with the gravity solids determination in the syrup. It is not practicable to use such a dilute solution when analyzing the molasses. The difficulty could be avoided by determining solids by drying, but this is also hardly practicable under present conditions.

4. Some volatilization of solids takes place during boiling operations.

Individually these discrepancies are not large. Unfortunately all are in the same direction, tending to make the calculated "available" smaller than it should be. Present information does not permit us to closely estimate the combined effect of these discrepancies. It seems probable, however, that 100 per cent of, or even slightly more than the calculated available, can be recovered in a well conducted factory. Notwithstanding the above discrepancies the calculations in Tables 6 and 7 are useful checks on the control, but it is necessary to bear in mind that the "available" as calculated is slightly less than the theoretically available.

Two factories have reported more than 101 per cent recovery on available, according to figures in Table 6. It may or may not be significant that these two factories were the two lowest in gravity purity of final molasses; a condition that would accentuate No. 3 of the factors mentioned above. Sucrose figures would have helped somewhat in deciding whether or not the high recoveries on available at these factories were due to errors in the control. In the absence of sucrose

TABLE NO. 6

APPARENT BOILING-HOUSE RECOVERY

Comparing percent available sucrose in the syrup (calculated by formula) with percent polarization actually obtained.

Factory	Available *	Obtained	Recovery on Available
H. C. & S. Co.	93.20	93.97	100.8
Oahu	91.79	92.02†	100.3
Ewa	92.03	91.49	99.4
Waialua	90.81	91.39	100.6
Pioneer	92.79	92.45	99.6
Olaa	92.10	92.66	100.6
Haw. Sug.	93.85	94.57	100.8
Maui Agr.	92.26	92.03†	99.8
Onomea	93.03	92.08	99.0
Lihue	90.96	92.37	101.6
Haw. Agr.	92.75	89.71	96.7
Hakalau	92.38	93.17	100.9
Kekaha	91.17	91.14	100.0
Hilo	91.29	91.74	100.5
Wailuku	92.50	92.53	100.0
McBryde	92.35	92.05	99.7
Makee	90.08	89.82	99.7
Honokaa	90.65	90.86	100.2
Laupahoehoe	92.43	91.26	98.7
Pepeekeo	93.17	92.41	99.2
Hamakua	90.07	89.03	98.8
Kahuku	90.76	91.87	101.2
Paauhau	91.80	90.70	98.8
Honomu	92.62	92.55	99.9
Koloa	88.90	87.61	98.5
Waiakea	91.90	91.60	99.7
Hutchinson	89.81	89.99	100.2
Hawi	92.89	89.17	96.0
Waianae	88.41	86.50	97.8
Kaiwiki	92.45	91.32	98.8
Kohala	91.69	91.02	99.3
Kilauea	89.89	89.28	99.3
Kaeleku	89.32	90.24	101.0
Waimanalo	90.11	90.13	100.0
Halawa	90.88	90.82	99.9
Union Mill	90.72	90.86	100.2
Waimea	90.99	85.09	93.5
Olowalu	89.29	83.65	93.7
Niulii	90.48	90.85	100.4

* In order to calculate the available sucrose it is necessary to estimate the gravity purity of the syrup and sugar. Data from factories determining both apparent and gravity purities indicate that the average correction necessary is the addition of 0.8 to the apparent purity of the syrup and 0.3 to the apparent purity of the sugar. One factory did not report moisture in sugar or gravity purity of molasses. In this case 1% and 38 have been used.

† Sucrose

TABLE NO. 7

TRUE BOILING-HOUSE RECOVERY

Comparing percent sucrose available and recovered

Factory	Available	Obtained	% Recovery on Available
H. C. & S. Co.	93.35	93.28	99.9
Oahu	91.79	91.98	100.2
Ewa	92.17	90.65	98.4
Waialua	90.95	90.44	99.4
Pioneer	92.87	91.88	98.9
Haw. Sug.	93.73	93.95	100.2
Maui Agr.	92.26	92.00	99.7
Onomea	92.85	91.79	98.9
Haw. Agr.	93.28	88.78	95.2
Hakalau	92.33	92.90	100.6
Hilo	90.97	91.77	100.9
Wailuku	92.40	91.97	99.5
McBryde	92.42	91.27	98.8
Makee	90.13	89.07	98.8
Honokaa	90.57	90.56	100.0
Laupahoehoe	92.43	91.09	98.5
Pepeekeo	93.08	92.09	98.9
Hamakua	90.01	88.50	98.3
Paauhau	91.78	90.48	98.6
Honomu	92.63	92.18	99.5
Waiakea	91.62	91.16	99.5
Hutchinson	89.77	89.36	99.5
Kilauea	89.26	88.89	99.6
Waimanalo	90.17	89.62	99.4
Union Mill	90.71	90.47	99.7

TABLE NO. 8

PERCENT MOLASSES PRODUCED ON THEORETICAL

H. C. & S. Co.	97.2	Laupahoehoe	79.2
Oahu	91.3	Pepeekeo	81.0
Ewa	86.2	Hamakua	93.1
Waialua	83.3	Kahuku	87.7
Pioneer	90.7	Paauhau	95.2
Olaa	88.3	Honomu	93.9
Haw. Sug.	98.5	Koloa	78.9
Onomea	90.7	Waiakea	91.0
Lihue	84.5	Hutchinson	88.4
Haw. Agr.	91.8	Hawi	120.7
Hakalau	87.9	Kaiwiki	101.0
Kekaha	92.4	Kohala	86.4
Hilo	90.3	Kilauea	84.8
Wailuku	92.1	Kaeleku	77.1
McBryde	99.0	Waimanalo	88.1
Makee	86.1	Union Mill	93.2
Honokaa	89.6	Olowalu	79.8

figures, these factories have not been included in Table 9, following former practice of omitting factories with over 101 per cent recovery on available in Table 6.

Boiling House Work

Clarification: The increase in purity from mixed juice to syrup for the factories averaged in Table 3 is 1.46 against 1.53 last year, a difference of .07. On this basis, the clarification is not quite as satisfactory as last year. With the exception of last year, however, the increase is better than in any year since 1919. Better increases in purity were secured at but 13 out of 36 factories reporting data necessary for a comparison. No decreases in purity have been reported in the last three years, though previously some decreases were almost invariably reported.

The average figure for lime used in all factories has decreased from .087 to .086. The decrease is largely on account of reductions at two of the Petree process factories. At the other factories (Table 3), lime used has increased .001 per cent. Changes in the amount used at individual factories are with few exceptions, small.

Information on the reaction, or changes in the reaction at which the clarification is conducted is desirable for judging to what extent results indicated by experimental work are secured in practice. At present the chemical control does not include determining reactions. The only information available on this point is the figure for the amount of lime used. This figure at best, is not particularly satisfactory. Both available CaO and the amount of CaO required to bring different juices to the most desirable reaction vary greatly. However, it is probable that these two factors are sufficiently equalized in the yearly average for all factories, to render figures for lime used reasonably satisfactory were it not for a third factor: the proportion of lime used in the settlings. This does seriously interfere with estimating changes in the reaction at which the clarification was conducted from changes in the amount of lime used. To illustrate the effect of this factor, let us take two cases. In one the juice is clarified with the amount of lime giving the largest increase in purity and no lime is used in the settlings. In the second case, with the same juice, the same total amount of lime is used, but a considerable proportion of the lime is added to the settlings. In the second case, the lime in the hot, strongly alkaline settlings reacts with insoluble organic matter. This neutralizes a part of the lime and adds to the soluble impurities in the juice. A further loss of lime, so far as its effect on clarification is concerned, takes place in the strongly alkaline press cake. In the second case, the clarification will be less alkaline even though the alkaline press juice is returned to the mixed juice. The increase in purity will be smaller, not only because the alkalinity will be below the most favorable point, but also because of organic matter dissolved by the lime.

In the last few years comparatively few factories have reported lime used in juice and in settlings separately, so we cannot judge from figures in the Synopsis whether more or less lime is now being used in the settlings. The writer would strongly recommend reporting lime used in settlings separately, as was the general

practice a few years back, for with the attention now given to clarification, this information is quite important.

But few factories can lime the juice at all times to the point where the maximum increase in purity is secured on account of the increase in the volume of settlings. An average liming is below the optimum point and as there has been an increase, though a small one, in the amount of lime used, a larger rather than a smaller increase in purity from mixed juice to syrup might be expected. Analysis of figures for individual factories does not disclose why the larger increase has not been secured. As just pointed out, however, the figures are incomplete as that they do not show changes in lime used in the settlings. A material increase in the amount of lime so used would account for the smaller increase in purity, for in this case, notwithstanding the slightly greater amount of lime used, the clarification would actually be less alkaline. There are some indications that this may have been the case. Increased grinding rate has probably necessitated a reduction in the volume of settlings to keep within the capacity of the filter presses. A reduction in the volume of settlings under otherwise equal conditions means a less alkaline clarification. Also in the last year or two it has been necessary at many factories to increase the lime in the settlings in order to handle the increased volume resulting from alkaline clarification with available filtration equipment. It is not unreasonable to suppose that, operating at a higher capacity this year, this tendency has continued. The increase in undetermined loss from .65 to .76 is also to some extent an indication of a less alkaline clarification, for the benefit of the change in clarification practice has been as much in decreased undetermined losses due to reduced losses through inversion as to the additional increase in purity secured in clarification.

The above discussion of results obtained in clarification has necessarily been with reference to averages for factories that do not use the Petree process (Table 3). Comparisons of the decrease in purity from first expressed juice to syrup can be made on the basis of averages for all factories. This figure represents the combined effect of conditions during milling and during clarification. Figures for this purity difference for the last few years follow:

Year	Purity Difference First Expressed Juice to Syrup
1921	2.32
1922	1.88
1923	1.40
1924	1.54

Averages for this decrease in purity are available as far back as 1914. The 1923 figure 1.40, is the same as the previous minimum figures in the years 1914 and 1918. This year's decrease, 1.54, is .14 larger than last year. It is, however, smaller than in 6 of the preceding ten years. Responsibility for the larger decrease is probably about equally divided between clarification and conditions at the mill.

This year's syrup purity, 86.32, is higher than in any year since 1917. Had the decrease in purity from first expressed juice to syrup been as small as it was

last year, the syrup purity would have been 86.46, a figure higher than in any year since 1915.

Filter Presses: Filter press operation was slightly more satisfactory than in the previous year. The quantity of press cake, .45 per cent, remains the same. The polarization was reduced from 2.20 to 2.16, reducing the loss in press cake per cent polarization of cane from .43 to .40.

Evaporation: The brix of the syrup, 63.32, is slightly better than last year. While slightly lower than in 1922, it is better than in other years for which we have a record. The amount of water evaporated per unit of time is some 3 per cent higher than last year. Water evaporated per cent mixed juice, however, is slightly lower due to higher juice densities.

Commercial Sugar: The average polarization of the sugar has increased from 96.90 to 97.18. This polarization is higher than in other years for which we have a record, except 1910, 1911 and 1912. The highest polarization on record was 97.55 in 1911. The increase of .28 in sugar polarization, at this year's syrup and molasses purities, is equivalent to a reduction of approximately .15 in recovery. This does not mean that less "available" sucrose is recovered with higher polarizations. Rather, the reduction in recovery corresponds to the smaller amount of molasses retained in the commercial sugar.

Moisture in the sugar has decreased from .83 to .75 per cent, or slightly more than in proportion to the increase in polarization, reducing the deterioration factor from .268 to .265. The latter figure is still slightly high in comparison with .25 which we consider the safe point.

Low Grade: Higher juice purities have tended to decrease the duty required of low grade equipment, while higher polarizing sugar and higher grinding rate have tended to increase it. The net effect has been an increase of from 10 to 12 per cent in the duty imposed on this equipment. The final molasses purity has increased from 37.90, the previous low point reached a year ago, to 38.16. The increase is without doubt largely on account of the extra work required of the low grade centrifugals. Notwithstanding higher molasses purity the influence of higher syrup purity has been sufficient to reduce the loss of sucrose in molasses per cent polarization of cane from 7.58 to 7.41. These are the lowest figures for loss in molasses since 1919.

Kahuku reports an average gravity purity for the season of 33.09, establishing a new record for molasses purity. The previous record, 33.16, was made by the same factory last year.

Table 8, showing the percentage of molasses on the theoretical, is largely a check on the chemical control. As in previous Synopses, the theoretical has been assumed to be gravity solids in the syrup minus gravity solids in the sugar. On this basis the difference between 100 and the molasses produced on the theoretical represents the "apparent" loss of gravity solids. All of this, however, is not a real loss of solids, a part of the apparent loss being caused by one of the factors (No. 3), discussed on a previous page, which influence the calculations in Tables 6 and 7.

Applying this calculation to averages for the past four years gives the following figures:

Year	Molasses Produced on Theoretical
1921	87.2
1922	86.3
1923	90.9
1924	90.8
Average	88.8

This table was first included in the Synopsis to call attention to the wide discrepancy in molasses figures reported from some factories. Since then there has been a tendency toward more consistent figures. While definite information is not available as to the range which should include figures for molasses produced on the theoretical as calculated above, it would appear that five points on each side of the average in the above tabulation should be sufficiently wide to include nearly if not all the correct figures. Certainly some of the figures in Table 8 are far enough outside this range to strongly indicate errors in the control.

Recoveries

Boiling house recovery in comparison with last season has increased from 91.28 to 91.39, an improvement of .11. The average for this year is higher than in any year since 1911. The total recovery, or recovery per cent polarization of cane, 88.94, is .17 higher than the previous high point reached last year.

The improvement in comparison with 1923 is to be credited to the improvement in the quality of the cane rather than to better factory work. On the basis of last year's work, higher juice purity this year would have increased the total recovery .64. However, the increase in sugar polarization is equivalent to a reduction of .15 in recovery, so if the work had been of the same quality as in 1923 the total recovery should have increased .49, making it 89.26 instead of 88.94. These figures indicate that the work this year has been less efficient than in 1923 by the equivalent of .32 in recovery. This difference of .32 between the recovery secured and what should have been secured had the work been of the same quality as last year is made up as follows: Higher extraction and smaller losses in press cake are the equivalent of an increase of approximately .10 in recovery. The larger decrease in purity from first expressed juice to syrup, due both to conditions at the mill and clarification is equivalent to a reduction of .12. Higher molasses purity is equivalent to a further reduction of .10. The difference between the sum of these factors and .32 is .20, attributable to larger undetermined losses and the unavoidable small discrepancies in figures of this kind.

The following are Quality Ratios and Tons Cane Required to make a Ton of Sugar for the past few years. Comparisons of these values are most conveniently made on the basis of the reciprocal of Tons Cane per Ton of Sugar

multiplied by 100, thus converting Tons of Cane per Ton of Sugar into sugar recovered per cent cane:

Years	Quality Ratio	Tons Cane Required	Sugar % Cane Theoretical	Recovered	Recovered % Theoretical	Gain Over 1921
1921	8.414	8.605	11.885	11.621	97.78	...
1922	8.448	8.617	11.837	11.605	98.04	.36
1923	8.573	8.556	11.665	11.688	100.20	2.42
1924	8.248	8.256	12.124	12.112	99.90	2.12

In 1923 the cane required to make a ton of sugar was .017 of a ton less than the quality ratio while in 1924, .008 of a ton more than the quality ratio was required, a net increase of .025 of a ton, so on the quality ratio basis also, slightly poorer work than last year is indicated. 1924 percentage figures in the above tabulations are lower than the 1923 figures by .3 per cent. However, a half of the difference is accounted for by the higher sugar polarization. Therefore the comparison on a quality ratio basis, corrected for the increase in sugar polarization, indicates less efficient work than last year by some .15 per cent; a figure somewhat more favorable than the .32 per cent arrived at on the basis of recovery calculations.

To recapitulate, in comparison with last year the cane has been of much better quality and the mills have ground at an increased capacity. Milling work has been of approximately the same quality, though slightly higher extraction has been secured. The decrease in purity from first expressed juice to syrup is larger, indicating less favorable conditions at the mill and in clarification. Filter press work has improved slightly. The molasses was not reduced to as low a purity but due to higher juice purities the loss in molasses was reduced. For the same reason recovery figures are higher. The net result of all these factors has been work some .15 to .3 per cent less efficient than last year. Though the work is somewhat poorer than last year, by far the greater part of the improvement made a year ago, over the comparatively poor work of 1920, 1921 and 1922 has still been realized.

In Table 9 the factories are ranked according to the ratio of recovery secured to a calculated recovery. Calculated recoveries used as the standard for comparisons are based on syrup and sugar purities as reported, 100 per cent extraction, 37.5 molasses purity and no other losses. The same standard was used last season. One hundred per cent has no particular significance except in the column headed Milling, for as molasses can be reduced to considerably below 37.5 gravity purity, figures higher than 100 may appear in the second or even in the third column.

The basis of comparison used in Table 9 is not free from criticism, but since the standard has been changed to close to average molasses purity the discrepancies have been greatly reduced. These figures should be considered an approximate gauge of the quality of the factory work. If closer distinctions are desired it is necessary to supplement figures in Table 9 with other data reported from the factories in question, for so far as the writer is aware neither this nor any other method so far proposed gives an accurate numerical value for "factory efficiency."

The calculations in this Synopsis have been made by Mr. Alex. Brodie, assisted by others in the Sugar Technology Department.

TABLE NO. 9.

COMPARISON OF ACTUAL AND CALCULATED RECOVERIES.

The factories are arranged in the order of the ratio of their recovery to that resulting from 100% extraction, reducing the molasses to 37.5 gravity purity, and eliminating all other losses. Factories reporting a recovery of over 101% of the available (Table No. 6) are omitted from this tabulation.

No.	Factory	Milling	Boiling House	Over All
1	Hakalau	98.90	101.43	100.46
2	Hononu	98.27	100.37	98.91
3	Pepeekeo	98.21	100.23	98.58
4	Hilo	98.60	99.78	98.51
5	Pioneer	98.06	99.87	98.25
6	Haw. Sug.	97.81	100.22	98.22
7	Onomea	98.89	98.82	97.91
8	Ewa	97.73	99.78	97.87
9	Oahu	97.51	99.77	97.70
10	Wailuku	98.07	99.26	97.61
11	H. C. & S. Co.	96.92	100.21	97.47
12	Kekaha	98.48	98.37	97.13
13	Waimanalo	98.87	98.05	97.13
14	Olaa	96.89	99.72	96.97
15	Makee	97.16	99.32	96.82
16	Waialua	96.71	99.58	96.71
17	Honokaa	96.49	99.79	96.70
18	Paauhau	97.51	98.78	96.64
19	McBryde	97.11	99.18	96.61
20	Maui Agr.	97.33	98.38	96.19
21	Kilauea	96.77	98.36	95.52
22	Hutchinson	96.88	97.72	95.19
23	Laupahoehoe	96.72	98.13	95.16
24	Kohala	96.39	97.95	94.72
25	Hamakua	97.36	96.87	94.68
26	Kaeleku	95.04	99.12	94.58
27	Koloa	96.83	97.12	94.57
28	Waiakea	95.27	98.18	93.94
29	Kaiwiki	96.35	97.12	93.79
30	Haw. Agr.	96.86	95.90	93.11
31	Waianae	96.88	95.48	92.88
32	Halawa	93.35	97.88	91.68
33	Hawi	95.90	94.83	91.38
34	Olowalu	97.99	92.51	90.96
35	Union Mill	92.87	97.17	90.72
36	Niulii	91.37	98.45	90.57
37	Waimea	97.07	92.92	90.48

TABLE NO. 10
SUMMARY OF LOSSES

FACTORY	POUNDS POLARIZATION PER TON OF CANE						POLARIZATION PER 100 CANE						POLARIZATION PER 100 POLARIZATION OF CANE						Syrup Purity	FACTORY
	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL		
H. C. & S. Co....	9.0	0.8	18.4	...	—1.6	26.6	0.45	0.04	0.92	...	—0.08	1.33	3.08	0.30	6.34	...	—0.52	9.20	87.91	H. C. & S. Co.
Oahu..........	7.0	0.6	20.4	...	1.6	29.6†	0.35	0.03	1.02	...	0.08	1.48†	2.49	0.21	7.22	...	0.55	10.47†	86.92	Oahu
Ewa...........	5.8	1.2	18.2	...	3.0	28.2	0.29	0.06	0.91	...	0.15	1.41	2.27	0.47	7.09	...	1.19	11.02	85.10	Ewa
Waialua........	8.8	1.4	20.0	...	2.4	32.6	0.44	0.07	1.00	...	0.12	1.63	3.29	0.55	7.43	...	0.85	12.12	85.1	Waialua
Pioneer.........	5.6	0.4	19.2	...	2.2	27.4	0.28	0.02	0.96	...	0.11	1.37	1.94	0.17	6.66	...	0.73	9.50	86.87	Pioneer
Olaa...........	8.0	1.2	17.2	...	1.0	27.4	0.40	0.06	0.86	...	0.05	1.37	3.11	0.47	6.70	...	0.38	10.66	86.8	Olaa
Haw. Sug.......	6.4	2.6	17.4	...	—1.8	24.6	0.32	0.13	0.87	...	—0.09	1.23	2.19	0.91	5.86	...	—0.60	8.36	87.82	Haw. Sug.
Maui Agr.......	8.0	...	....	...	23.2	31.2†	0.40	...	...	...	1.16	1.56†	2.67	...	....	...	7.75	10.42†	88.90	Maui Agr.
Onomea........	2.8	0.2	17.2	...	2.6	22.8	0.14	0.01	0.86	...	0.13	1.14	1.11	0.09	6.82	...	1.01	9.03	87.72	Onomea
Lihue..........	6.0	0.6	18.0	...	0.6	25.2*	0.30	0.03	0.90	...	0.03	1.26*	2.38	0.28	7.18	...	0.25	10.09*	83.62	Lihue
Haw. Agr.......	7.4	0.4	18.4	...	5.2	31.4	0.37	0.02	0.92	...	0.26	1.57	3.14	0.20	7.78	...	2.16	13.28	87.74	Haw. Agr.
Hakalau........	2.8	0.2	16.8	...	0.6	20.4	0.14	0.01	0.84	...	0.03	1.02	1.10	0.11	6.52	...	0.23	7.96	85.9	Hakalau
Honolulu.......	7.2	0.4	27.0	1.2	...	....	0.36	0.02	1.35	0.06	...	...	2.55	0.13	9.51	0.40	....	....	86.62	Honolulu
Kekaha.........	4.2	1.6	22.6	...	1.4	29.8	0.21	0.08	1.13	...	0.07	1.49	1.52	0.61	8.18	...	0.49	10.80	86.2	Kekaha
Hilo...........	3.4	0.8	18.8	...	0.8	23.8	0.17	0.04	0.94	...	0.04	1.19	1.40	0.37	7.77	...	0.35	9.89	86.33	Hilo
Wailuku........	5.2	1.2	18.6	...	1.0	26.0	0.26	0.06	0.93	...	0.05	1.30	1.93	0.43	6.89	...	0.40	9.65	87.2	Wailuku
McBryde........	8.0	0.8	21.2	...	...	30.0	0.40	0.04	1.06	...	....	1.50	2.89	0.29	7.70	...	....	10.88	86.63	McBryde
Makee..........	7.0	0.8	21.2	...	3.0	32.0	0.35	0.04	1.06	...	0.15	1.60	2.84	0.35	8.62	...	1.23	13.04	84.27	Makee
Honokaa........	8.0	0.8	19.0	...	1.2	29.0	0.40	0.04	0.95	...	0.06	1.45	3.51	0.35	8.25	...	0.54	12.65	84.39	Honokaa
Laupahoehoe....	8.4	0.4	16.2	...	5.2	30.2	0.42	0.02	0.81	...	0.26	1.51	3.28	0.11	6.37	...	2.07	11.83	87.33	Laupahoehoe
Pepeekeo.......	4.6	0.4	14.6	...	4.2	23.8	0.23	0.02	0.73	...	0.21	1.19	1.79	0.14	5.79	...	1.65	9.37	86.2	Pepeekeo
Hamakua........	6.6	...	24.4	...	2.2	33.2	0.33	...	1.22	...	0.11	1.66	2.64	...	9.82	...	0.86	13.32	86.02	Hamakua
Kahuku.........	8.4	1.2	19.2	...	0.2	29.0*	0.42	0.06	0.96	...	0.01	1.45*	3.37	0.53	7.71	...	0.10	11.71*	82.25	Kahuku
Paauhau........	6.0	0.6	19.4	...	2.2	28.2	0.30	0.03	0.97	...	0.11	1.41	2.49	0.23	8.15	...	0.90	11.77	85.5	Paauhau
Honomu.........	4.4	0.8	17.8	...	0.8	23.8	0.22	0.04	0.89	...	0.04	1.19	1.73	0.32	6.97	...	0.32	9.34	86.3	Honomu
Koloa..........	8.0	2.0	23.2	...	7.2	40.4	0.40	0.10	1.16	...	0.36	2.02	3.17	0.80	9.06	...	2.83	15.86	83.2	Koloa
Waiakea........	12.6	1.2	19.4	...	1.6	34.8	0.63	0.06	0.97	...	0.08	1.74	4.73	0.48	7.36	...	0.60	13.17	87.19	Waiakea
Hutchinson.....	7.2	1.0	20.6	...	1.8	30.6	0.36	0.05	1.03	...	0.09	1.53	3.12	0.43	8.91	...	0.75	13.21	85.79	Hutchinson
Hawi...........	11.2	1.0	28.0	...	...	40.2	0.56	0.05	1.40	...	....	2.01	4.10	0.34	10.33	...	0.02	14.79	87.8	Hawi
Waianae........	8.4	1.8	...	...	35.2	45.4	0.42	0.09	...	...	1.76	2.27	3.12	0.68	....	...	12.99	16.79	83.43	Waianae
Kaiwiki........	9.4	2.0	20.6	...	0.8	32.8	0.47	0.10	1.03	...	0.04	1.64	3.65	0.76	8.01	...	0.28	12.70	87.61	Kaiwiki
Kohala.........	9.2	2.4	18.6	...	3.4	33.6	0.46	0.12	0.93	...	0.17	1.68	3.61	0.97	7.24	...	1.34	13.16	86.03	Kohala
Kilauea........	8.0	2.4	21.4	...	4.2	36.0	0.40	0.12	1.07	...	0.21	1.80	3.23	0.97	8.57	...	1.70	14.47	83.4	Kilauea
Kaeleku........	11.8	1.4	18.4	...	3.4	35.0	0.59	0.07	0.92	...	0.17	1.75	4.96	0.57	7.76	...	1.46	14.75	84.04	Kaeleku
Waimanalo......	3.0	2.2	22.8	...	3.0	31.0	0.15	0.11	1.14	...	0.15	1.55	1.13	0.80	8.59	...	1.09	11.61	84.93	Waimanalo
Halawa.........	16.0	2.8	...	...	20.4	39.2	0.80	0.14	...	...	1.02	1.96	6.65	1.21	....	...	8.46	16.32	85.18	Halawa
Union Mill.....	18.0	3.2	20.4	...	0.6	42.2	0.90	0.16	1.02	...	0.03	2.11	7.13	1.29	8.13	...	0.23	16.78	86.3	Union Mill
Waimea.........	7.8	1.0	...	...	38.4	47.2	0.39	0.05	...	...	1.92	2.36	2.92	0.41	....	...	14.42	17.75	85.44	Waimea
Olowalu........	5.2	1.2	27.2	...	14.8	48.4	0.26	0.06	1.36	...	0.74	2.42	2.01	0.43	10.31	...	5.64	18.39	83.2	Olowalu
Niulii.........	20.6	1.0	...	...	20.0	41.6	1.03	0.05	...	...	1.00	2.08	8.63	0.46	....	...	8.32	17.41	85.41	Niulii

* A comparison of the available sucrose in the juice with the amount recovered in the boiling house indicates that there is probably an error in some of the results reported from this factory.

† Sucrose.

Sugar Prices

96° Centrifugals for the Period

September 19 to December 15, 1924

Date	Per Pound	Per Ton	Remarks
Sept. 19, 1924	5.795¢	$115.90	Cubas, 5.81, 5.78.
" 25	6.03	120.60	Cubas.
Oct. 30	5.96	119.20	Cubas.
" 31	5.90	118.00	Cubas.
Nov. 3	5.78	115.60	Cubas.
" 11	5.59	111.80	Cubas.
" 12	5.715	114.30	Cubas, 5.65, 5.78.
" 18	5.90	118.00	Cubas.
" 19	5.93	118.60	Cubas, 5.90, 5.96.
" 20	5.90	118.00	Cubas.
" 24	6.03	120.60	Spot Cubas.
" 28	6.06	121.20	Cubas, 6.03, 6.09.
Dec. 1	6.03	120.60	Cubas.
" 4	6.15	123.00	Spot Cubas.
" 6	5.84	116.80	Cubas.
" 9	5.59	111.80	Cubas, 5.65, 5.53.
" 11	5.02	100.40	Porto Ricos.
" 15	4.90	98.00	Cubas.

ANNUAL SYNOPSIS OF MILL DATA—SHOWING RESULTS FROM 40 HAWAIIAN FACTORIES FOR CROP OF 1924

Factory	Factory No.	Milling Plant (Sizes in Inches)	Cane: Polarization	Cane: % Fiber	Cane: Tons per ton commercial sugar	Cane: Tons ground per hour	Cane: Tonnage ratio	Bagasse: Polarization	Bagasse: % Moisture	Bagasse: % Fiber	Bagasse: Pol. per 100 cane	Bagasse: Pol. per 100 pol. of cane	Bagasse: Pol. per 100 Fiber "Milling Loss"	Bagasse: Weight per 100 cane	Factory No.	First Expressed Juice: Brix	First Expressed Juice: Polarization	First Expressed Juice: Purity	First Expressed Juice: Pol. of cane x 100 / Polarization
H. C. & S. Co.**	6	K(4),2RC78(2),S72(2),12RM78(2)	14.54	12.00	7.33	61.25‡	1.74	2.03	42.97	54.27	0.45	3.08	3.72	22.13	6	20.00	17.91	89.55	81.2
Oahu	20	K(2),2RC78(2),S72(2),12RM78(2)	14.11	12.16	7.72	53.44‡	1.52	1.62	41.53	56.04	0.35	2.49	2.89	21.70	20	19.67	17.29	87.90	81.6
Ewa	5	K(2),2RC78,18RM78	12.77	12.30	8.54	76.04	1.54	1.26	44.63	53.48	0.29	2.27	2.36	23.00	5	18.30	15.76	86.12	81.0
Waialua	17	K(2),2RC78,12RM78	13.49	13.25	8.18	65.40	1.86	1.86	41.91	55.43	0.44	3.29	3.36	23.90	17	18.82	16.53	87.8	81.6
Pioneer	10	K,2RC72,S72,15RM72	14.44	12.12	7.48	76.88	2.14	1.26	43.73	54.40	0.28	1.94	2.22	22.28	10	20.47	18.21	88.96	79.3
Olaa	36	K,S72,12RM78	12.84	12.70	8.48	51.7	1.84	1.69	44.04	53.55	0.40	3.11	3.16	23.64	36	17.64	15.50	87.9	82.8
Haw. Sug.	16	K,2RC72,S72,12RM78	14.81	12.08	7.15	44.01	1.25	1.52	41.51	56.45	0.32	2.19	2.69	21.38	16	19.99	17.83	89.19	83.1
Maui Agr.**	21	K(2),3RC66,18RM66	14.95	11.09	7.29	71.63	2.03	1.75	46.13	51.28	0.40	2.67	3.41	22.80	21	19.26	17.12	88.89	87.3
Onomea	34	2RC60,S54,12RM66	12.65	12.04	8.46	41.97	1.67	0.67	38.45	60.54	0.14	1.11	1.11	20.89	34	16.69	14.85	89.00	85.2
Lihue	27	K,2RC78,S72,12RM78	12.52	12.04	8.61	60.14	1.71	1.35	40.74	57.25	0.30	2.38	2.36	22.08	27	18.57	15.99	86.1	78.3
Haw. Agr.††	30	3RC60,12RM66	11.87	12.93	9.42	46.95	1.87	1.67	39.74	58.07	0.37	3.14	2.88	22.27	30	16.63	14.76	88.76	80.4
Hakalau	7	2RC54,12RM9-60,3 66	12.81	12.32	8.26	31.22	1.50	0.71	36.53	62.47	0.14	1.10	1.14	19.72	7	17.18	15.13	88.1	84.6
Honolulu	13	K(2),S54,2RC78,9RM78	14.22	11.83	8.19	42.97	1.53	1.77	39.84	57.64	0.36	2.55	3.07	20.52	13	19.81	17.25	87.1	82.4
Kekaha	25	2RC54,15RM60	13.82	12.22	7.88	35.53	1.42	1.00	40.45	58.04	0.21	1.52	1.72	21.05	25	18.89	16.82	89.0	82.2
Hilo	33	K,2RC60,12RM66	12.05	13.85	9.03	38.64	1.53	0.74	38.58	60.40	0.17	1.40	1.22	22.93	33	15.99	13.79	86.24	87.4
Wailuku	2	K,2RC72,12RM78	13.43	12.75	8.02	38.16	1.08	1.26	36.13	62.03	0.26	1.93	2.04	20.55	2	18.80	16.97	90.3	79.1
McBryde	12	K,2RC72,S72,9RM84	13.78	14.16	7.87	38.56	1.18	1.61	40.39	57.37	0.40	2.89	2.81	24.68	12	19.58	17.14	87.54	80.4
Makee	14	2RC72,S72,9RM72	12.32	13.02	9.11	51.04	2.13	1.49	39.82	58.12	0.35	2.84	2.56	23.43	14	18.21	15.73	86.38	78.3
Honokaa	35	K(2),2RC66,12RM66	11.52	12.72	9.63	38.62	1.53	1.67	45.16	52.44	0.40	3.51	3.18	24.25	35	16.65	14.40	86.49	80.0
Laupahoehoe	41	K,2RC60,9RM60	12.78	12.78	8.62	27.68	1.66	1.85	41.01	56.55	0.42	3.28	3.27	22.61	41	16.99	15.13	89.05	84.5
Pepeekeo	19	2RC54,9RM60	12.70	12.54	8.46	26.39	1.58	1.10	38.65	59.87	0.23	1.79	1.84	20.62	19	17.25	15.22	88.2	83.4
Hamakua**	15	K,2RC60,12RM60	12.45	14.16	8.99	27.63	1.33	1.28	43.02	55.12	0.33	2.64	2.32	25.66	15	18.26	16.19	88.66	76.9
Kaauka	43	2RC60,S54,9RM72	12.39	15.79	8.87	28.21	1.18	1.48	41.74	55.85	0.42	3.37	2.65	28.22	43	18.28	15.49	84.74	80.0
Paauhau	24	2RC60,12RM66	11.88	12.49	9.26	29.66	1.18	1.36	38.10	59.91	0.30	2.49	2.27	21.69	24	17.25	15.05	87.2	78.9
Honomu	37	3RC60,9RM60	12.71	12.44	8.49	24.63	1.48	1.07	38.00	60.34	0.22	1.73	1.77	20.62	37	17.33	15.25	88.0	83.3
Koloa	38	K,2RC60,12RM66	12.74	13.56	9.07	33.73	1.34	1.70	40.16	57.16	0.40	3.17	2.98	23.73	38	19.24	16.33	84.9	78.0
Waiakea	3	K,2RC60,9RM60	13.22	14.39	8.46	26.29	1.58	2.39	41.74	55.09	0.63	4.73	4.34	26.11	3	18.63	16.56	88.89	79.8
Hutchinson††	31	2RC60,9RM60	11.61	11.80	9.63	27.39	1.64	1.73	40.93	56.38	0.36	3.12	3.07	20.95	31	16.09	14.06	87.38	82.6
Hawi	26	K(2),3RC48,12RM3-48,9-54	13.57	12.81	8.34	24.79	1.47	2.35	42.68	54.15	0.56	4.10	4.34	23.65	26	18.83	16.86	89.5	80.5
Waianae	9	K(2),12RM60	13.56	13.07	8.58	26.71	1.60	1.72	41.87	55.57	0.42	3.12	3.10	24.60	9	20.19	17.37	86.03	78.1
Kaiwiki	32	K,2RC60,9RM60	12.82	13.60	8.64	26.08	1.56	2.00	39.29	58.17	0.47	3.65	3.44	23.38	32	18.29	16.36	89.45	78.4
Kohala	40	K(2),3RC60,9RM60	12.80	13.04	8.72	26.43	1.59	1.99	41.20	56.12	0.46	3.61	3.55	23.23	40	17.69	15.46	87.39	82.8
Kilauea††	23	K,S,2RC60,9RM60	12.47	14.32	9.07	24.51	1.47	1.64	39.42	58.24	0.40	3.23	2.82	24.59	23	18.98	16.29	85.8	76.6
Kaeleku	47	K,2RC54,9RM60	11.89	14.10	9.52	26.29	1.58	2.39	39.20	57.58	0.59	4.96	4.15	24.64	47	17.22	14.76	85.72	80.6
Waimanalo	1	K,3RC54,9RM54	13.31	13.41	8.24	24.47	1.81	0.69	37.26	61.68	0.15	1.13	1.12	21.75	1	18.42	15.98	86.75	83.3
Halawa	29	K,2RC60,6RM50	12.01	13.82	9.59	14.09	1.62	3.26	39.34	56.51	0.80	6.65	5.77	24.45	29	17.14	14.65	85.48	82.0
Union Mill	11	K,9RM60	12.59	13.60	9.22	21.23	1.69	3.39	44.32	51.27	0.90	7.13	6.59	26.52	11	17.7	15.49	87.5	91.3
Waimea	4	2RC48,12RM42	13.32	11.95	8.89	13.29	1.30	1.85	40.45	56.79	0.39	2.92	3.26	21.04	4	18.58	16.09	86.60	82.8
Olowalu	18	K,3RC48,9RM48	13.17	12.96	8.94	16.64	1.56	1.21	39.11	59.05	0.26	2.01	2.05	21.94	18	18.95	16.35	86.3	80.5
Niulii	39	K,9RM54	11.98	13.75	9.73	17.46	1.72	3.54	48.29	47.03	1.03	8.63	7.53	29.24	39	16.67	14.43	86.56	83.0
True Average, 1924			13.26	12.74	8.26	....	....	1.56	41.58	56.19	0.35	2.67	2.78	22.67	1924	18.51	16.26	87.86	81.6
" " 1923			12.78	12.82	8.56	....	....	1.55	41.56	56.18	0.35	2.77	2.76	22.80	1923	18.09	15.75	87.05	81.1
" " 1922			12.97	12.95	8.62	....	....	1.69	41.51	56.05	0.39	3.02	3.02	23.09	1922	18.44	16.01	86.84	81.0
" " 1921			13.12	12.80	8.61	....	....	1.50	41.20	56.58	0.34	2.57	2.64	22.58	1921	18.74	16.16	86.22	81.2
" " 1920			13.64	12.64	8.12	....	....	1.56	41.05	56.68	0.35	2.55	2.75	22.29	1920	19.32	16.85	87.24	80.9
" " 1919			13.74	12.49	7.94	....	....	1.67	41.57	56.05	0.37	2.70	2.97	22.27	1919	19.17	16.74	87.34	82.0
" " 1918			12.97	12.50	8.51	....	....	1.59	42.70	55.04	0.36	2.79	2.90	22.74	1918	18.26	15.92	87.18	81.3
" " 1917			13.76	12.62	8.03	....	....	1.78	42.26	55.31	0.41	2.95	3.22	22.83	1917	19.14	16.85	88.02	81.6
" " 1916			13.45	12.74	8.16	....	....	1.81	42.49	54.98	0.42	3.13	3.31	23.19	1916	18.64	16.34	87.70	82.3
" " 1915			13.77	12.51	7.98	....	....	2.17	43.87	53.07	0.51	3.72	4.09	23.57	1915	18.87	16.65	88.24	82.7

Factory	Mixed Juice: Brix	Mixed Juice: Polarization	Mixed Juice: Purity	Mixed Juice: Weight per 100 cane	Mixed Juice: Pol. per 100 cane	Mixed Juice: Pol. per 100 pol. of cane "Extraction"	Extraction Ratio	Last Expressed Juice: Polarization	Last Expressed Juice: Purity	Maceration Water: Weight per 100 cane	Maceration Water: Dilution % normal juice
H. C. & S. Co.	14.62	12.86	87.96	109.27	14.09	96.92	0.26	2.48	73.32	31.40	34.06
Oahu	14.18	12.22*	86.18	112.61	13.76	97.51	0.20	1.90	66.35	33.31	31.86
Ewa	13.23	10.99	83.07	113.54	12.48	97.73	0.18	1.26	66.67	36.34	33.18
Waialua	13.58	11.45	84.3	113.59	13.04	96.71	0.25	2.04	76.0	37.79	36.60
Pioneer	15.50	13.52	85.94	102.21	13.82	95.99	0.16	2.74	67.03	29.60	29.42
Olaa	13.53	11.37	84.0	109.40	12.44	96.89	0.24	1.26	70.0	33.04	30.3
Haw. Sug.	13.89	11.88	85.53	121.07	14.49	97.81	0.18	1.59	74.65	43.35	42.19
Maui Agr.	13.89	12.29*	88.18	118.56	14.55	97.33	0.23	3.11	67.85	41.16	37.29
Onomea	12.46	10.74	86.20	116.51	12.51	98.89	0.09	1.31	66.50	37.40	35.31
Lihue	14.26	11.87	83.2	102.98	12.22	97.62	0.19	1.82	67.0	25.06	25.06
Haw. Agr.	13.23	11.43	86.39	100.55	11.50	96.86	0.24	2.69	76.64	22.82	19.61
Hakalau	11.90	10.14	85.2	124.90	12.67	98.90	0.09	1.19	71.3	44.61	44.37
Honolulu	13.56	11.57	85.33	121.88	13.86	97.45	0.20	1.09	70.2	42.40	42.48
Kekaha	13.54	11.50	84.9	118.26	13.63	98.48	0.12	0.74	66.1	39.41	37.59
Hilo	11.91	10.11	84.87	117.58	11.88	96.60	0.19	1.50	72.48	40.51	38.49
Wailuku	13.59	11.64	85.7	113.17	13.17	98.07	0.15	1.30	68.6	33.72	32.60
McBryde	12.96	10.90	84.10	122.22	13.33	97.11	0.20	1.98	71.74	44.40	47.92
Makee	13.00	10.91	83.90	109.75	11.97	97.16	0.21	1.51	72.29	33.19	31.23
Honokaa	12.19	10.12	83.02	109.85	11.11	96.49	0.25	2.03	73.08	32.08	31.1
Laupahoehoe	12.24	10.52	86.02	117.49	12.36	96.72	0.25	2.78	75.75	40.10	39.62
Pepeekeo	13.22	11.24	85.0	110.95	12.47	98.21	0.15	1.84	74.2	31.57	28.44
Hamakua	14.80	12.70	85.82	95.47	12.12	97.50	0.18	2.52	68.07	21.13	14.86
Kaauka	12.68	10.86	85.65	117.01	12.67	96.63	0.21	1.35	61.50	43.23	39.84
Paauhau	12.58	10.14	80.6	110.24	11.18	97.51	0.18	2.21	68.34	32.63	31.32
Honomu	12.77	11.00	86.1	116.22	12.40	97.07	0.18	1.61	64.6	36.94	35.71
Koloa	13.91	11.30	81.2	108.22	12.23	96.13	0.26	1.21	63.4	32.05	....
Waiakea	13.82	11.90	86.11	103.80	12.59	95.27	0.35	2.98	75.26	31.91	30.54
Hutchinson	12.20	10.27	84.18	109.55	11.25	96.85	0.22	1.46	64.35	30.50	20.10
Hawi	14.62	12.71	86.94	101.60	12.66	96.29	0.25	3.05	74.8	23.55	22.43
Waianae	12.87	10.47	81.35	125.46	13.14	96.88	0.25	2.97	67.19	50.06	50.89
Kaiwiki	12.93	11.18	86.47	110.46	12.35	96.05	0.27	2.80	78.87	33.84	33.10
Kohala	12.68	10.71	84.46	115.22	12.34	96.59	0.28	1.68	72.31	38.45	37.93
Kilauea	14.11	11.90	84.34	105.01	12.52	96.69	0.28	2.40	78.70	29.63	27.29
Kaeleku	13.36	11.08	82.93	102.02	11.30	95.04	0.35	4.20	74.26	26.66	25.75
Waimanalo	13.10	10.95	83.59	120.17	13.16	98.82	0.08	1.09	65.14	41.88	40.69
Halawa	13.31	11.18	84.0	100.25	11.21	93.35	0.48	6.85	78.56	24.70	25.54
Union Mill	14.1	11.98	84.96	97.57	11.69	92.87	0.52	5.28	76.5	24.09	25.54
Waimea	14.14	11.95	84.51	108.20	12.93	97.07	0.24	2.39	71.90	29.24	27.44
Olowalu	13.47	11.03	81.9	117.02	12.91	97.80	0.16	1.87	62.2	38.97	37.86
Niulii	13.58	11.42	84.10	95.88	10.95	91.37	0.63	5.21	75.65	25.12	22.76
True Average, 1924	13.52	11.50	85.05	112.23	12.91	97.23	0.22	1.96	71.62	34.80	....
" " 1923	13.13	11.06	84.27	112.32	12.43	97.25	0.22	1.79	68.71	33.12	....
" " 1922	13.46	11.31	84.02	111.48	12.61	97.43	0.20	1.66	69.13	32.75	....
" " 1921	13.25	10.97	82.77	116.50	12.79	97.43	0.20	1.68	65.93	36.30	....
" " 1920	13.48	11.31	83.87	117.35	13.29	97.45	0.20	1.65	68.20	36.95	....
" " 1919	13.39	11.24	83.96	113.58	12.70	97.18	0.22	1.70	68.53	34.80	....
" " 1918	12.92	10.85	83.99	116.05	12.60	97.21	0.22	1.56	69.52	38.09	....
" " 1917	13.48	11.45	84.95	113.64	13.01	96.86	0.25	1.71	71.74	34.59	....
" " 1916	13.17	11.14	84.60	116.09	12.93	96.72	0.26	1.75	71.71	35.85	....
" " 1915	14.03	11.89	84.75	111.44	13.26	96.30	0.30	1.96	73.88	35.04	....

Factory No.	Clarified juice purity	Syrup: Brix	Syrup: Purity	Syrup: Increase in Purity	Press Cake: Polarization	Press Cake: Weight per 100 cane	Press Cake: Pol. per 100 cane	Press Cake: Pol. per 100 pol. of cane	Lime Used (Weight Per 100 Cane): In Juice	Lime Used: In Settlings	Lime Used: Total
6	87.96	65.34	87.91	...	3.36	0.81	0.04	[illegible]	[illegible]	[illegible]	0.07
20	86.36	61.99	86.92	0.74*	1.54	1.94	0.03	[illegible]	[illegible]	0.02	0.10
5	84.07	67.98	85.10	2.03	2.34	2.58	0.06	[illegible]	[illegible]	0.01	0.07
17	86.3	63.25	85.1	0.8	2.75	2.69	0.07	[illegible]	...	...	0.12
10	86.94	61.42	86.87	0.93	0.80	3.05	0.02	[illegible]	[illegible]	[illegible]	[illegible]
36	86.8	65.54	86.8	2.8¶	3.97	1.52	0.06	0.47	...	...	0.07
16	87.35	67.74	87.82	2.29	7.39	1.83	0.13	[illegible]	0.04	0.04	0.08
21	88.48	65.33	88.90	..	...	...	...	[illegible]	[illegible]	[illegible]	0.10
34	87.50	66.28	87.72	1.52	0.44	2.50	0.01	[illegible]	[illegible]	[illegible]	0.07
27	83.8	60.20	83.62	0.42	1.62	2.13	0.03	[illegible]	...	..	0.10
30	87.54	58.42	87.74	1.35	1.13	2.13	0.02	[illegible]	[illegible]	...	[illegible]
7	85.7	66.26	85.9	0.7	0.45	3.20	0.01	[illegible]	[illegible]	[illegible]	[illegible]
13	86.9	56.86	86.62	2.79¶	0.59	3.17	0.02	[illegible]	[illegible]	[illegible]	0.10
25	86.1	65.47	86.2	1.5	2.88	2.94	0.08	[illegible]	[illegible]	[illegible]	0.10
33	86.16	66.70	86.33	1.46	1.92	2.28	0.04	[illegible]	...	...	0.07
2	86.8	57.87	87.2	1.5	2.14	2.70	0.06	0.43	...	...	0.19
12	85.70	62.90	86.63	2.53	2.35	1.71	0.04	[illegible]	[illegible]	[illegible]	[illegible]
14	84.87	59.65	84.27	0.34	1.58	2.75	0.04	[illegible]	[illegible]	[illegible]	[illegible]
35	84.16	61.68	84.39	1.37	1.95	2.10	0.04	[illegible]	[illegible]	[illegible]	[illegible]
41	87.34	65.36	87.33	1.38	0.65	2.22	0.02	[illegible]	[illegible]	[illegible]	[illegible]
19	86.2	69.17	86.2	1.2	0.74	2.42	0.02	[illegible]	[illegible]	[illegible]	[illegible]
15	85.82	72.94	86.02	..	...	...	...	..	[illegible]	[illegible]	[illegible]
43	82.21	63.00	82.25	1.57	2.69	2.43	0.06	[illegible]	[illegible]	[illegible]	[illegible]
24	85.4	66.72	85.5	2.5¶	1.16	2.39	0.03	[illegible]	[illegible]	[illegible]	[illegible]
37	85.4	72.78	86.3	2.2	1.74	2.31	0.04	[illegible]	[illegible]	[illegible]	0.07
38	83.3	61.67	83.2	1.3	5.21	3.17	0.10	[illegible]	[illegible]	[illegible]	[illegible]
3	87.16	54.04	87.19	1.08¶	2.27	2.76	0.06	[illegible]	...	...	0.10
31	85.05	67.57	85.79	1.61	2.18	2.30	0.05	[illegible]	[illegible]	[illegible]	0.07
26	88.0	78.93	87.8	0.5	1.85	2.52	0.05	[illegible]	[illegible]	[illegible]	[illegible]
9	83.78	63.06	83.43	2.08	3.66	2.52	0.09	[illegible]	[illegible]	[illegible]	[illegible]
32	87.50	58.70	87.61	1.14¶	2.97	3.29	0.10	[illegible]	[illegible]	[illegible]	[illegible]
40	86.29	57.20	86.03	1.57	3.55	3.49	0.12	[illegible]	[illegible]	[illegible]	[illegible]
23	82.9	54.72	83.4	2.0	4.07	2.96	0.12	[illegible]	[illegible]	[illegible]	[illegible]
47	84.12	56.88	84.04	1.11	3.17	2.13	0.07	[illegible]	[illegible]	[illegible]	[illegible]
1	85.26	60.72	84.93	1.34¶	3.58	2.99	0.11	[illegible]	[illegible]	[illegible]	0.11
29	85.07	59.35	85.18	1.18	4.71	3.07	0.14	1.21	0.07	...	0.07
11	85.4	60.9	86.3	1.34	5.25	3.08	0.16	1.29	0.08	0.01	0.09
4	84.86	61.16	85.44	0.93	2.25	2.44	0.05	[illegible]	[illegible]	[illegible]	[illegible]
18	83.2	65.84	83.2	1.5	2.5	2.41	0.06	[illegible]	[illegible]	[illegible]	[illegible]
39	84.90	60.23	85.41	1.31	2.85	1.95	0.05	[illegible]	[illegible]	[illegible]	[illegible]
1924	....	63.32	86.52	1.27	2.26	2.16	0.05	0.3	[illegible]	[illegible]	[illegible]
1923	....	63.26	85.65	1.58	2.31	2.22	0.05	0.4	[illegible]	...	[illegible]
1922	....	62.27	84.96	1.23	2.57	2.65	0.07	0.5	[illegible]	....	[illegible]
1921	....	62.09	83.90	1.13	1.66	2.58	0.04	0.3	[illegible]	...	[illegible]
1920	....	61.34	85.20	1.33	1.65	2.63	0.04	0.3	[illegible]	..	[illegible]
1919	....	62.42	85.70	1.41	1.34	2.32	0.03	0.2	[illegible]	..	[illegible]
1918	....	61.66	85.78	1.79	1.48	2.36	0.03	0.2	[illegible]	.	[illegible]
1917	....	62.28	86.36	1.48	1.52	2.28	0.03	0.2	..	...	[illegible]
1916	....	62.73	86.18	1.50	1.82	2.20	0.04	0.3	.	...	[illegible]
1915	....	61.61	86.59	1.84	1.81	1.89	0.03	0.2	.	.	[illegible]

Factory No.	Commercial Sugar: Polarization	Commercial Sugar: % Moisture	Commercial Sugar: Weight per 100 cane	Commercial Sugar: Pol. per 100 cane	Commercial Sugar: Pol. per 100 pol. of cane	Commercial Sugar: Pol. per 100 pol. of juice	Commercial Sugar: Total weight in thousand tons	Final Molasses: Weight per 100 cane	Final Molasses: Sucrose per 100 cane	Final Molasses: Sucrose per 100 pol. of cane	Final Molasses: Sucrose per 100 pol. of juice	Final Molasses: Gravity solids	Final Molasses: Gravity purity	Final Molasses: True purity	Other Known Losses: Pol. per 100 cane	Other Known Losses: Pol. per 100 pol. of cane	Undetermined Losses: Pol. per 100 cane	Undetermined Losses: Pol. per 100 pol. of cane	Factory
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	97.78*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	97.07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	96.59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
36	97.24	0.78	11.79	11.47	90.34	93.81	29	2.53	0.97	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	97.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	96.92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	97.11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
33	98.10	0.70	11.07	10.90	91.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	97.32	0.63	12.47	12.14	90.35	92.13	18	2.71	0.63	0.69	7.03	88.81	33.31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Wailuku
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	McBryde
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	97.15	0.78	11.82	11.48	90.82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	97.08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	96.33	1.0	10.43	10.05	83.63	88.54	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	96.59	1.18	10.85	10.48	83.22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1924	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1923	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1922	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1921	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1920	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1919	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1918	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1917	96.87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1916	96.21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1915	96.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* Sucrose.
† Refined sugar.
‡ For one mill only.
¶ Probably influenced by low grade sugar in syrup.
§ 1924 crop unfinished.
** Petree process.
†† Balance of 1923 crop included.

CANE MILL DATA. SEASON OF 1924

Revolving Knives

Factory	Factory No.	Milling Plant (Sizes in Inches)	First Set: Number	First Set: Distance Apart, Inches	First Set: Distance from Conveyor, Inches	First Set: Revolutions per Minute	Second Set: Number	Second Set: Distance Apart, Inches	Second Set: Distance from Conveyor, Inches	Second Set: Revolutions per Minute
H. C. & S. Co.	6	K(2),2RC34x78,S72,12RM34x78	28	9 3/4	24	1200	56	5	16	1200
" "	6	K(2),2RC34x78,S72,12RM34x78	28	9 3/4	24	1200	56	5	16	1200
Oahu	20	K,2RC34x78,S72,12RM34x78	26	5	19	490	..	....	....	....
"	20	K,2RC34x78,S72,12RM34x78	28	4 1/2	18	690	..	....	....	....
Ewa	5	K(2),2RC33x78,18RM34x78	72	2	16	580	72	2	2 1/2	580
Waialua	17	K(2),2RC33x78,12RM34x78	24	5 1/2	12	650	72	1 7/8	5	650
Pioneer	10	K,2RC34x72,S72,15RM34x72	27	2 1/4	16	690	..	....	....	....
Olaa	36	K,S72,12RM34x78	36	1 7/8	4	450	..	....	....	....
Haw. Sug.	16	K,2RC28x72,S72,12RM34x78	32	4	15	450	..	....	....	....
Maui Agr.	21	K(2),3RC34x66,18RM34x66	72	7/8	10	450	72	7/8	7/8	520
Onomea	34	2RC28x60,S54,12RM32x66	..	....	....	....	..	....	....	....
Lihue	27	K,2RC34x78,S72,12RM34x78	10	7	10	350	..	....	....	....
Haw. Agr.	30	3RC32x60,12RM32x66	..	....	....	....	..	....	....	....
Hakalau	7	2RC24x54,12RM9-32x60,3-32x66	..	....	....	....	..	....	....	....
Honolulu	13	K(2),S54,2RC32x78,9RM34x78	24	6	18	380	24	6	4	420
Kekaha	25	2RC24x54,15RM32x60	..	....	....	....	..	....	....	....
Hilo	33	K,2RC24x60,12RM32x66	10	6	10	200	..	....	....	....
Wailuku	2	K,2RC28x72,12RM34x78	10	6	18	400	..	....	....	....
McBryde	12	K,2RC34x72,S72,9RM34x84	24	8	16	400	..	....	....	....
Makee	14	2RC34x72,S72,9RM34x72	..	....	....	....	..	....	....	....
Honokaa	35	K(2),2RC30x66,12RM32x66	98	1 1/2	19	440	84	17/32	10	540
Laupahoehoe	41	K,2RC30x60,9RM32x60	16	3 1/2	3	450	..	....	....	....
Pepeekeo	19	2RC24x54,9RM32x60	..	....	....	....	..	....	....	....
Hamakua	15	K,2RC30x60,12RM32x60	48	4	1 1/2	400	..	....	....	....
Kahuku	43	2RC26x60,S54,9RM34x72	..	....	....	....	..	....	....	....
Paauhau	24	2RC26x60,12RM32x66	..	....	....	....	..	....	....	....
Honomu	37	3RC33x60,9RM32x60	..	....	....	....	..	....	....	....
Koloa	38	K,2RC27x60,12RM32x66	24	5	9	300	..	....	....	....
Waiakea	3	K,2RC28x60,9RM32x60	38	6	4 1/2	380	..	....	....	....
Hutchinson	31	2RC30x60,9RM32x60	..	....	....	....	..	....	....	....
Hawi	26	K(2),3RC26x48,12RM3-26x48,9-30x54	14	3 1/4	2 1/2	485	8	5	6	525
Waianae	9	K(2),12RM9-30x60,3-32x60	12	4 1/2	10	525	22	2 1/2	6	525
Kaiwiki	32	K,2RC24x60,9RM32x60	18	3	2	350	..	....	....	....
Kohala	40	K(2),3RC30x60,9RM32x60	12	4 1/2	20	300	37	4 1/2	2	300
Kilauea	23	K,S,3RC31x60,9RM32x60	10	6	2	250	..	....	....	....
Kaeleku	47	K,2RC24x54,9RM32x60	9	6	8	250	..	....	....	....
Waimanalo	1	K,3RC32x54,9RM30x54	28	1 7/8	4	475	..	....	....	....
Halawa	29	K,2RC30x60,6RM26x50	20	5	1 1/2	375	..	....	....	....
Union Mill	11	K,9RM30x60	16	3 3/4	1 1/2	200	..	....	....	....
Waimea	4	2RC24x48,12RM26x42	..	....	....	....	..	....	....	....
Olowalu	18	K,3RC28x48,9RM27x48	16	4	1 1/2	400	..	....	....	....
Niulii	39	K,9RM30x54	9	6	6 1/2	500	..	....	....	....

Mill Openings

Factory	Factory No.	Crusher	1st Mill Front	1st Mill Back	2nd Mill Front	2nd Mill Back	3rd Mill Front	3rd Mill Back	4th Mill Front	4th Mill Back	5th Mill Front	5th Mill Back
H. C. & S. Co.	6	1/16	7/16	1/16	5/16	1/32	5/16	0	7/16	0	...	...
" "	6	1/16	7/16	1/16	5/16	1/32	5/16	0	7/16	0	...	...
Oahu	20	5/16	3/8	0	5/8	0	1/2	0	3/8	0	...	...
"	20	5/16	5/16	0	3/8	0	1/2	0	3/8	0	...	...
Ewa	5	3/8	1	3/16	3/4	1/8	3/4	1/8	5/8	1/16	1/2	0 †
Waialua	17	5/8	7/16	0	5/16	0	1/4	0	1/4	0	...	...
Pioneer	10	1/16	3/8	1/16	3/8	0	3/8	0	3/8	0	3/8	0
Olaa	36	....	7/8	3/16	9/16	1/8	3/8	0	5/16	0	...	...
Haw. Sug.	16	1/4	7/16	1/16	3/8	0	5/16	0	1/4	0	...	...
Maui Agr.	21	7/16x1/16	13/16	0	9/16	0	1/4	0	5/8	3/16	1/2	0 ‡
Onomea	34	1/4	1/2	1/16	3/8	0	3/8	0	1/4	0	...	...
Lihue	27	1/16	7/16	1/16	7/16	0	3/8	0	3/8	0	...	...
Haw. Agr.	30	1 3/4x3/8	5/8	1/8	5/8	1/8	1/2	1/16	3/8	0	...	...
Hakalau	7	1/4	3/4	0	3/16	0	1/8	0	1/4	0	...	...
Honolulu	13	1/4	3/4	1/2	1/2	0	1/2	0	...	...	...	...
Kekaha	25	1/2	7/8	1/8	5/8	3/32	1/2	1/16	7/16	1/32	3/8	0
Hilo	33	3/8	5/8	0	1/4	0	1/4	0	3/8	0	...	...
Wailuku	2	1/16	3/16	0	3/8	0	5/16	0	3/16	0	...	...
McBryde	12	1/4	7/16	0	3/8	0	1/4	0	...	...	...	...
Makee	14	0	7/16	0	3/8	0	3/8	0	...	...	...	...
Honokaa	35	3/4	5/8	3/16	1/2	5/32	3/8	1/8	5/16	1/16	...	...
Laupahoehoe	41	3/8	3/8	0	5/16	0	1/4	0	...	...	...	...
Pepeekeo	19	0	1/2	0	3/32	0	3/32	0	...	...	...	...
Hamakua	15	1/2	1/2	0	3/8	0	1/4	0	3/16	0	...	...
Kahuku	43	3/8	3/16	0	1/8	0	3/16	0	...	...	...	...
Paauhau	24	0	3/8	0	1/4	0	3/16	0	3/16	0	...	...
Honomu	37	9/16x0	1/4	0	3/16	0	1/8	0	...	...	...	...
Koloa	38	1/8	3/4	1/16	1/2	1/32	3/8	0	5/16	0	...	...
Waiakea	3	1/16	11/16	0	5/16	0	1/4	0	...	...	...	...
Hutchinson	31	7/16	7/16	0	1/8	0	1/8	0	...	...	...	...
Hawi	26	3/4x5/16	3/8	1/16	3/16	0	1/16	0	1/16	0	...	...
Waianae	9	....	5/16	0	3/8	0	7/16	0	3/8	0	...	...
Kaiwiki	32	3/16	3/8	0	5/16	0	1/8	0	...	...	...	...
Kohala	40	3/4x3/8	3/8	0	1/8	0	1/16	0	...	...	...	...
Kilauea	23	3/8x1/8	1/4	0	1/4	0	1/8	0	...	...	...	...
Kaeleku	47	0	3/4	0	1/4	0	1/8	0	...	...	...	...
Waimanalo	1	3/4x1/8	1/4	0	1/4	0	1/4	0	...	...	...	...
Halawa	29	3/8	5/16	0	1/8	0	...	...	...	...	...	...
Union Mill	11	....	5/8	1/8	3/8	3/32	3/16	0	...	...	...	...
Waimea	4	0	1/2	1/8	7/16	1/8	1/4	0	1/4	0	...	...
Olowalu	18	5/8x1/4	1/4	0	1/4	0	1/4	0	...	...	...	...
Niulii	39	....	9/16	1/8	1/4	1/16	5/16	0	...	...	...	...

Returner Bar — Distance from Top Roller — Inches

Factory	Factory No.	Crusher Toe	Crusher Center	Crusher Heel	1st Mill Toe	1st Mill Center	1st Mill Heel	2nd Mill Toe	2nd Mill Center	2nd Mill Heel	3rd Mill Toe	3rd Mill Center	3rd Mill Heel	4th Mill Toe	4th Mill Center	4th Mill Heel	5th Mill Toe	5th Mill Center	5th Mill Heel
H. C. & S. Co.	6	.....	.....	.....	1 1/4	1 3/4	2 1/4	1 1/4	1 3/4	2 1/4	1 1/4	1 3/4	2 1/4	1 1/4	1 3/4	2 1/4	....	....	....
" "	6	.....	.....	.....	1 1/4	1 3/4	2 1/4	1 1/4	1 3/4	2 1/4	1 1/4	1 3/4	2 1/4	1 1/4	1 3/4	2 1/4	....	....	....
Oahu	20	.....	.....	.....	1 1/8	1 9/16	1 3/4	1 3/16	1 1/2	1 3/4	1 5/16	1 1/2	1 11/16	1 1/8	1 3/16	1 9/16	....	....	....
"	20	.....	.....	.....	1 5/16	1 9/16	1 5/8	1 3/8	1 5/8	1 3/4	1 1/4	1 9/16	1 3/4	1 1/8	1 7/16	1 11/16	....	....	....
Ewa	5	.....	.....	.....	1 1/2	1 3/4	2	1 1/2	1 3/4	2	1 1/2	1 3/4	2	1 3/4	1 7/8	2	1 1/2	1 3/4	2
Waialua	17	.....	.....	.....	7/8	7/8	1 3/8	1/2	5/8	1 1/4	1/2	5/8	1 1/4	1/2	3/4	1 1/2	....	....	....
Pioneer	10	.....	.....	.....	1 3/8	1 5/8	1 3/4	1 1/4	1 1/2	1 5/8	1 1/4	1 1/2	1 5/8	1 1/4	1 1/2	1 5/8	1 1/4	1 1/2	1 5/8
Olaa	36	.....	.....	.....	1 1/4	1 3/8	1 3/4	1	1 1/8	1 5/8	1	1 1/8	1 1/2	7/8	1	1 3/8	....	....	....
Haw. Sug.	16	.....	.....	.....	1 1/4	1 1/2	1 3/4	1 1/4	1 1/2	1 3/4	1 1/4	1 1/2	1 3/4	1 1/8	1 3/8	1 5/8	....	....	....
Maui Agr.	21	....	1 1/2	.....	.....	1 1/2	....	.....	1 1/2	.....	.....	1 5/8	.....	.....	1 1/2	.....	....	1 1/2	....
Onomea	34	.....	.....	.....	1 1/8	1 3/8	1 1/2	1	1 1/4	1 1/2	1	1 1/4	1 1/2	7/8	1	1 1/4	....	....	....
Lihue	27	.....	.....	.....	7/8	1 3/4	1 3/4	1 1/8	1 1/2	2	1	1 1/2	2	1	1 3/8	2	....	....	....
Haw. Agr.	30	1 5/8	1 3/4	1 7/8	1 1/2	1 5/8	1 3/4	1 3/8	1 1/2	1 5/8	1 1/4	1 3/8	1 1/2	1 1/8	1 1/4	1 3/8	....	....	....
Hakalau	7	.....	.....	.....	1	1 1/2	2 1/4	7/16	1	2	3/8	7/8	2	1/2	1	2	....	....	....
Honolulu	13	.....	.....	.....	1 1/2	1 5/8	1 3/4	1 3/8	1 1/2	1 5/8	1 1/4	1 3/8	1 1/2	.....	.....	.....	....	....	....
Kekaha	25	.....	.....	.....	.....	2 1/4	....	.....	2 1/4	.....	.....	2	.....	.....	1 3/4	.....	....	1 1/2	....
Hilo	33	.....	.....	.....	1	1 1/8	1 1/2	1	1 1/4	1 5/8	1	1 3/8	1 5/8	7/8	1 3/16	1 1/2	....	....	....
Wailuku	2	.....	.....	.....	1 1/4	1 1/2	1 3/4	1 1/4	1 1/2	1 3/4	1 1/4	1 1/2	1 3/4	1 1/4	1 1/2	1 3/4	....	....	....
McBryde	12	.....	.....	.....	1 1/4	1 1/2	2	1 1/2	1 3/4	2	1 1/2	1 3/4	2	.....	.....	.....	....	....	....
Makee	14	.....	.....	.....	1	1 1/2	2	1	1 1/2	2	1	1 1/2	2	.....	.....	.....	....	....	....
Honokaa	35	.....	.....	.....	1 3/16	1 1/4	1 1/2	1 3/8	1 1/2	2	3/4	1 1/4	1 3/4	1 1/4	1 1/2	1 3/4	....	....	....
Laupahoehoe	41	.....	.....	.....	1	1 3/8	1 5/8	7/8	1 1/8	1 3/8	5/8	3/4	1 1/8	.....	.....	.....	....	....	....
Pepeekeo	19	.....	.....	.....	1	1 1/8	1 1/4	3/4	1 1/16	1 7/8	1 5/16	1 1/8	2 1/8	.....	.....	.....	....	....	....
Hamakua	15	.....	.....	.....	1 1/4	1 1/2	1 3/8	1 1/4	1 1/2	1 3/4	1 1/8	1 3/8	1 5/8	1	1 1/4	1 1/2	....	....	....
Kahuku	43	.....	.....	.....	3/4	1	1 3/4	3/8	1	1 1/2	1/2	3/4	1 3/8	.....	.....	.....	....	....	....
Paauhau	24	.....	.....	.....	1 5/16	1 11/16	2 3/16	1 1/4	1 7/16	1 15/16	1 9/16	1 7/16	2 1/16	1 1/16	1 9/16	2 7/16	....	....	....
Honomu	37	1/2	5/8	1	1/2	1	1 1/8	1/2	7/8	1	1/2	3/4	1	.....	.....	.....	....	....	....
Koloa	38	.....	.....	.....	1 1/4	1 3/4	2	1 1/4	1 1/2	1 3/4	1 1/4	1 1/2	1 3/4	1 1/4	1 1/2	1 3/4	....	....	....
Waiakea	3	.....	.....	.....	1 1/4	1 3/8	1 7/8	1	1 1/8	1 5/8	3/4	15/16	1 5/16	.....	.....	.....	....	....	....
Hutchinson	31	.....	.....	.....	3/4	1 1/4	1 5/8	3/4	1	1 1/4	7/8	1 1/8	1 3/8	.....	.....	.....	....	....	....
Hawi	26	1 1/16	1 1/4	1 3/8	1	1 1/4	1 1/2	7/8	1	1 3/8	3/4	1	1 1/4	3/4	1	1 1/4	....	....	....
Waianae	9	.....	.....	.....	1	1 1/2	2	7/8	1 1/4	1 3/4	7/8	1 1/8	1 3/4	5/8	1	1 1/2	....	....	....
Kaiwiki	32	.....	.....	.....	3/4	1	1 1/4	1 1/8	1 1/4	1 3/8	1 1/4	1 1/2	1 3/4	.....	.....	.....	....	....	....
Kohala	40	1 1/2	1 3/4	2 1/4	3/8	1 1/8	1 5/8	1/2	1 1/8	1 3/4	3/8	1	1 3/8	.....	.....	.....	....	....	....
Kilauea	23	1 9/16	1 11/16	1 15/16	1 1/8	1 1/2	1 3/4	1	1 1/2	2	1 1/8	1 1/2	2	.....	.....	.....	....	....	....
Kaeleku	47	.....	.....	.....	1 1/4	1 1/2	1 3/4	1	1 1/4	1 1/2	3/4	1	1 1/4	.....	.....	.....	....	....	....
Waimanalo	1	5/8	7/8	1 1/8	1	1 1/4	1 1/2	1	1 1/4	1 1/2	1	1 1/4	1 1/2	.....	.....	.....	....	....	....
Halawa	29	.....	.....	.....	5/8	1	1 1/2	5/8	13/16	1 1/8	.....	.....	.....	.....	.....	.....	....	....	....
Union Mill	11	.....	.....	.....	1 3/8	1 5/8	1 3/4	1 5/16	1 3/8	1 3/8	1	3/4	1 1/4	.....	.....	.....	....	....	....
Waimea	4	.....	.....	.....	1 1/4	1 1/2	1 3/4	1 3/4	1 1/2	1 3/4	27/32	31/32	1 9/32	11/16	15/16	1 15/16	....	....	....
Olowalu	18	3/4	15/16	1 1/4	1	1 1/4	1 1/2	5/8	7/8	1 1/4	11/16	7/8	1 1/8	.....	.....	.....	....	....	....
Niulii	39	.....	.....	.....	2	2 1/4	3	1 1/4	1 3/4	2	1 1/4	1 1/2	1 3/4	.....	.....	.....	....	....	....

Returner Bar — Width — Inches; Distance from Back Roller — Inches

Factory	Factory No.	Width 1st Mill	Width 2nd Mill	Width 3rd Mill	Width 4th Mill	Width 5th Mill	Width 6th Mill	Back Roller 1st Mill	Back Roller 2nd Mill	Back Roller 3rd Mill	Back Roller 4th Mill	Back Roller 5th Mill	Back Roller 6th Mill
H. C. & S. Co.	6	13	12 1/4	12 1/4	12 1/4	......	......	1/2	1/2	1/2	1/2	...	...
" "	6	13	12 1/4	12 1/4	12 1/4	......	......	1/2	1/2	1/2	1/2	...	...
Oahu	20	13 1/4	14 1/2	13 3/4	14	......	......	3/8	1/4	1/2	1/2	...	...
"	20	14 1/2	16 1/2	14 1/2	13 1/8	......	......	1 3/8	7/8	5/8	1	...	...
Ewa	5	13	13	13	13	13	13	7/8	3/4	5/8	3/4	3/4	5/8
Waialua	17	13	12 3/8	12 3/8	11 1/4	......	......	1	5/8	3/4	1/2	...	...
Pioneer	10	12 3/4	12	12 3/8	12 3/4	12 3/4	......	5/8	9/16	9/16	5/8	9/16	...
Olaa	36	15	15	14 1/2	12 1/2	......	......	5/8	5/8	5/8	1/2	...	...
Haw. Sug.	16	12 3/4	12 3/4	13	13 1/4	......	......	3/8	3/8	3/8	3/8	...	...
Maui Agr.	21	12	12	12	12	12	12	5/16	3/4	1/2	3/4	1/2	1/2
Onomea	34	12	12	11 1/2	12 1/2	......	......	1/4	1/2	3/8	1/4	...	...
Lihue	27	13 3/8	14	14	12 1/2	......	......	1/2	1/2	1/2	1/2	...	...
Haw. Agr.	30	13	11 1/2	11	11 1/2	......	......	1/2	1/2	1/2	3/8	...	...
Hakalau	7	12 1/4	12	12 1/4	12	......	......	1/2	3/8	3/8	3/8	...	...
Honolulu	13	13	11 1/4	12	......	......	......	5/8	3/4	1/2	...	...	...
Kekaha	25	......	......	......	......	......	......	1/2	1/2	1/2	1/2	1/2	...
Hilo	33	12	11 3/4	12 1/4	11 3/4	......	......	1/2	1/4	1/4	1/4	...	...
Wailuku	2	12	13 1/8	14 1/4	14 1/4	......	......	3/4	5/8	5/8	5/8	...	...
McBryde	12	12 1/2	13	13	......	......	......	1/2	1/2	3/8	...	...	...
Makee	14	13	13	13	......	......	......	1/4	1/4	1/8	...	...	...
Honokaa	35	10	10	12	11 1/2	......	......	1 1/8	1	3/4	3/4	...	...
Laupahoehoe	41	12 1/2	11 1/4	11 3/4	......	......	......	7/8	1	1	...	...	...
Pepeekeo	19	14 1/2	13 1/2	12 1/8	......	......	......	1/2	1/2	1/2	...	...	...
Hamakua	15	12 1/2	12 1/2	12 1/4	11 1/2	......	......	1/2	1/2	1/2	1/2	...	...
Kahuku	43	14	15	12 1/4	......	......	......	1/4	1/4	1/4	...	...	...
Paauhau	24	11 1/4	11 1/4	11	12	......	......	7/16	1 1/16	7/8	5/8	...	...
Honomu	37	12	12 3/4	13	......	......	......	3/4	13/16	13/16	...	...	...
Koloa	38	12	10 1/2	10	10	......	......	3/8	3/8	1/2	1/2	...	...
Waiakea	3	12 1/2	12 1/2	12 1/2	......	......	......	1/4	1/4	1/4	...	...	...
Hutchinson	31	11	10 3/4	11 1/2	......	......	......	5/8	1/2	1/2	...	...	...
Hawi	26	10 1/2	11 1/2	11 1/2	11 1/2	......	......	1/2	3/4	3/4	3/4	...	...
Waianae	9	12 1/2	13	12 1/2	13	......	......	3/4	3/4	5/8	1/2	...	...
Kaiwiki	32	11 7/8	11 1/4	11 1/4	......	......	......	3/4	5/8	1/2	...	...	...
Kohala	40	14	14	12	......	......	......	3/4	3/4	3/4	...	...	...
Kilauea	23	11 1/2	11 1/2	12 1/4	......	......	......	3/4	1 1/16	3/8	...	...	...
Kaeleku	47	12 3/4	12	12 1/2	......	......	......	1/2	1/2	1/2	...	...	...
Waimanalo	1	11 1/4	11 1/4	11 1/4	......	......	......	1/2	1/2	1/2	...	...	...
Halawa	29	10 1/2	10 1/2	......	......	......	......	3/8	3/8	...	...	...	...
Union Mill	11	11 1/2	11 1/2	10 3/4	......	......	......	11/16	5/8	9/16	...	...	...
Waimea	4	9	11	10	10	......	......	1 1/4	1	3/4	3/4	...	...
Olowalu	18	10	10 1/2	10	......	......	......	3/4	1/2	5/8	...	...	...
Niulii	39	12 1/2	10	12	......	......	......	1/8	1 3/8	5/8	...	...	...

Speed of Rollers — Feet per Minute; Pressure on Rollers — Tons

Factory	Factory No.	Speed Crusher	Speed 1st Mill	Speed 2nd Mill	Speed 3rd Mill	Speed 4th Mill	Speed 5th Mill	Speed 6th Mill	Pressure Crusher	Pressure 1st Mill	Pressure 2nd Mill	Pressure 3rd Mill	Pressure 4th Mill	Pressure 5th Mill	Pressure 6th Mill	Tons Cane per Hour	Tonnage Ratio
H. C. & S. Co.	6	30	25	27.5	30.3	32	....	....	300	420	450	475	525	....	....	61.25*	1.74
" "	6	30	25	27.5	30.3	32	....	....	300	420	450	475	525	....	....		
Oahu	20	30.7	26.5	18.3	20.9	21.4	....	....	218	454	454	430	446	....	....	53.44*	1.52
"	20	30.7	25.5	17.6	20	20.7	....	....	300	350	337	387	437	....	....		
Ewa	5	18.9	17.6	20	21.5	24.2	27.7	31.6	370	450	360	450	420	450	450	76.04	1.54
Waialua	17	28.4	26.4	21.2	24	25.9	....	....	300	440	430	420	440	....	....	65.40	1.86
Pioneer	10	51.9	30.1	31.3	23.9	27.3	31.4	....	260	453	407	332	340	357	....	76.88	2.14
Olaa	36	...	25	25.2	28.8	33.1	....	....	....	420	420	420	445	....	....	51.7	1.84
Haw. Sug.	16	24.5	14.9	17.0	17.7	19.1	....	....	280	498	490	490	502	....	....	44.01	1.25
Maui Agr.	21	23	23.5	25.2	28.8	23.5	25.2	28.8	450	340	350	486	260	230	380	71.63	2.03
Onomea	34	29.8	23.2	23.2	23.2	23.2	....	....	....	428	400	400	410	....	....	41.97	1.67
Lihue	27	28.2	17.6	17.1	17.1	18.8	....	....	290	470	410	430	460	....	....	60.14	1.71
Haw. Agr.	30	21.5	19.3	20.2	22.3	24	....	....	370	402	380	409	500	....	....	46.95	1.87
Hakalau	7	30.5	21.6	24.2	26.5	15.8	....	....	....	322	322	345	380	....	....	31.22	1.50
Honolulu	13	17.4	16.6	18.7	20.4	....	....	....	250	450	420	450	....	....	....	42.97	1.53
Kekaha	25	20	17.3	19	20.3	21	22	....	....	351	373	382	353	361	....	35.53	1.42
Hilo	33	26.5	18.6	20.9	22.8	13.3	....	....	....	395	395	395	430	....	....	38.64	1.53
Wailuku	2	30.3	18.3	16.8	17.8	22.3	....	....	....	400	360	360	360	....	....	38.16	1.08
McBryde	12	26	18	18	18	....	....	....	250	400	503	525	....	....	....	38.56	1.18
Makee	14	25.9	22.5	25.7	29.5	....	....	....	250	450	475	475	....	....	....	51.04	2.13
Honokaa	35	25.6	18.4	15.2	18.5	20.3	....	....	192	338	301	297	354	....	....	38.62	1.53
Laupahoehoe	41	23.6	16.4	17.6	18.9	....	....	....	250	374	374	374	....	....	....	27.68	1.66
Pepeekeo	19	31.4	17.9	19.7	21.6	....	....	....	....	380	380	380	....	....	....	26.39	1.58
Hamakua	15	25	15.7	18.1	20.2	21.8	....	....	....	360	316	333	370	....	....	27.63	1.33
Kahuku	43	16.8	12.4	14.2	16.4	....	....	....	187	434	398	499	....	....	....	28.21	1.18
Paauhau	24	24.6	15.1	14.3	15.9	17.5	....	....	....	406	370	370	401	....	....	29.66	1.18
Honomu	37	21.1	18.3	21	23.3	....	....	....	295	318	318	318	....	....	....	24.63	1.48
Koloa	38	22.5	17.5	19	17.5	19	....	....	140	400	380	400	400	....	....	33.73	1.34
Waiakea	3	24.7	16.7	18.9	22	....	....	....	150	323	281	340	....	....	....	26.29	1.58
Hutchinson	31	23.7	18.7	20.7	22.9	....	....	....	....	415	362	390	....	....	....	27.39	1.64
Hawi	26	16	18	16	18	18	....	....	170	170	242	259	333	....	....	24.79	1.47
Waianae	9	...	16.9	16.9	16.9	18.8	....	....	....	277	291	291	340	....	....	26.71	1.60
Kaiwiki	32	20.3	16.9	19.5	21.3	....	....	....	....	381	338	324	....	....	....	26.08	1.56
Kohala	40	25	18	20.2	25.2	....	....	....	....	359	365	385	....	....	....	26.43	1.59
Kilauea	23	18	19.5	26.5	20.5	....	....	....	300	320	310	312	....	....	....	24.51	1.47
Kaeleku	47	19.8	16.6	18	20.4	....	....	....	....	329	340	340	....	....	....	26.29	1.58
Waimanalo	1	19.5	18.5	18.5	18.5	....	....	....	348	348	348	348	....	....	....	24.47	1.81
Halawa	29	12.8	16	11.8	....	....	....	....	165	172	186	....	....	....	....	14.09	1.62
Union Mill	11	...	15.2	13.6	13.4	....	....	....	....	295	262	299	....	....	....	21.23	1.69
Waimea	4	20	13.6	14.1	13.6	17	....	....	....	215	....	154	154	....	....	13.29	1.30
Olowalu	18	23.1	23.1	30.8	30.8	....	....	....	202	202	220	220	....	....	....	16.64	1.56
Niulii	39	...	16.2	19.8	19.8	....	....	....	....	165	174	183	....	....	....	17.46	1.72

*Tons of cane per hour for one tandem.
†6th Mill. Openings 1/4x0, returner bar from top roller, 1 1/2, 1 3/4, 1 7/8.
‡6th Mill. Openings 1/16x0, returner bar from top roller, center 1 5/8.

CANE MILL DATA, SEASON OF 1924 (CONTINUED) ROLLER GROOVING

Factory	Factory No.	MILLING PLANT	SURFACE GROOVES PER INCH. TOP, FRONT, BACK. Crusher	1st Mill	2nd Mill	3rd Mill	4th Mill	5th Mill	6th Mill
H. C. & S. Co.	6	K(2),2RC78,S72,12RM78	Krajewski	1 1/3, 1 1/3, 1 1/3	8, 1 1/3, 8	8, 1 1/3, 8	8, 1 1/3, 8	....	....
" "	6	K(2),2RC78,S72,12RM78	Krajewski	1 1/3, 1 1/3, 1 1/3	8, 1 1/3, 8	8, 1 1/3, 8	8, 1 1/3, 8	....	....
Oahu	20	K,2RC78,S72,12RM78	Krajewski	2 2/3, 1 1/3, 2 2/3	2 2/3, 1 1/3, 2 2/3	2 2/3, 1 1/3, 2 2/3	7, 1 1/3, 7	....	....
"	20	K,2RC78,S72,12RM78	Krajewski	2 2/3, 1 1/3, 2 2/3	2 2/3, 1 1/3, 2 2/3	2 2/3, 2 2/3, 2 2/3	7, 2 2/3, 7	....	....
Ewa	5	K(2),2RC78,18RM78	1,1	1 1/3, 1 1/3, 1 1/3	2 2/3, 1 1/3, 5 1/3	5 1/3, 1 1/3, 5 1/3	5 1/3, 1 1/3, 5 1/3	5 1/3, 1 1/3, 5 1/3	5 1/3, 1 1/3, 5 1/3
Waialua	17	K(2),2RC78,12RM78	4/5, 4/5	2 2/3, 1 1/3, 2 2/3	1 1/3, 2 2/3, 1 1/3	2 2/3, 2 2/3, 2 2/3	2 2/3, 2 2/3, 2 2/3	....	....
Pioneer	10	K,2RC72,S72,15RM72	Krajewski	1 1/3, 1 1/3, 1 1/3	7, 1 1/3, 7	7, 1 1/3, 7	7, 1 1/3, 7	7, 1 1/3, 7	....
Olaa	36	K,S72,12RM78	....	2 2/3, 3, 6	6,1 1/3, 6	6, 3, 6	6, 3, 6	....	....
Haw. Sug	16	K,2RC72,S72,12RM78	Krajewski	4, 4, 4	7, 4, 7	4, 4, 4	7, 6, 7	....	....
Maui Agr	21	K(2),3RC66,18RM66	1 1/2, 1 1/2, 1 1/2	6, 6, 6	6, 6, 6	6, 6, 6	6, 6, 6	6, 6, 6	6, 6, 6
Onomea	34	2RC60,S54,12RM66	Krajewski	7, 5, 7	7, 4, 7	7, 4, 7	7, 4, 7	....	....
Lihue	27	K,2RC78,S72,12RM78	Krajewski	1 1/3, 1 1/3, 2 2/3	7, 1 1/3, 7	5, 1 1/3, 7	5, 1 1/3, 5	....	....
Haw. Agr	30	3RC60,12RM66	2/3, 2/3, 2/3	3/4, 3/4, 3/4	2 1/2, 2 1/2, 2 1/2	5, 5, 5	5, 2 1/2, 5	....	....
Hakalau	7	2RC54,12RM9-60,3-66	Krajewski	5, 5, 5	7, 7, 7	7, 7, 7	7, 7, 7	....	....
Honolulu	13	K(2),S54,2RC78,9RM78	2/3, 2/3	1 1/3, 1 1/3, 1 1/3	6, 6, 6	6, 6, 6	....	....	....
Kekaha	25	2RC54,15RM60	Krajewski	2/3, 2/3, 2/3	7, 7, 7	7, 7, 7	7, 7, 7	7, 7, 7	....
Hilo	33	K,2RC60,12RM66	Krajewski	2 1/2, 5, 5	5, 5, 5	5, 5, 5	5, 5, 5	....	....
Wailuku	2	K,2RC72,12RM78	Krajewski	1 1/3, 1 1/3, 1 1/3	4, 4, 4	4, 4, 4	4, 4, 4	....	....
McBryde	12	K,2RC72,S72,9RM84	Krajewski	6, 1 1/3, 6	6, 6, 6	6, 6, 6	....	....	....
Makee	14	2RC72,S72,9RM72	Krajewski	3, 3, 7	3, 3,7	7, 7, 7	....	....	....
Honokaa	35	K(2),2RC66,12RM66	2/3, 2/3	5, 3 1/2, 3 1/2	5, 5, 5	5, 5, 5	5, 5, 5	....	....
Laupahoehoe	41	K,2RC60,9RM60	2/3, 2/3	5, 4, 5	6, 4, 6	7, 4, 7	....	....	....
Pepeekeo	19	2RC54,9RM60	Krajewski	5, 7, 7	5, 7, 7	5, 7, 7	....	....	....
Hamakua	15	K,2RC60,12RM60	Krajewski	6, 6, 6	6, 6, 6	6, 6, 6	6, 6, 6	....	....
Kahuku	43	2RC60,S54,9RM72	Krajewski	4, 4, 4	4, 4, 4	4, 4, 7	....	....	....
Paauhau	24	2RC60,12RM66	Krajewski	4, 2 2/3, 4	7, 4, 7	7, 7, 7	7, 4, 7	....	....
Honomu	37	3RC60,9RM60	2/3, 2/3, 2/3	6, 6, 6	5, 6, 5	5, 6, 6	....	....	....
Koloa	38	K,2RC60,12RM66	Krajewski	2 5/8, 2 5/8, 5 1/4	5 1/4, 2 5/8, 5 1/4	5 1/4, 2 5/8, 5 1/4	5 1/4, 2 5/8, 5 1/4	....	....
Waiakea	3	K,2RC60,9RM60	——	4, 4, 7	7, 4, 7	7, 4, 7	....	....	....
Hutchinson	31	2RC60,9RM60	2/3, 2/3	5, 5, 5	5, 5, 5	5, 5, 5	....	....	....
Hawi	26	K(2),3RC48,12RM3-48,9-54	3 1/2, 4/5, 3	3 1/2, 4/5, 3	3 1/2, 4/5, 3 1/2	3 1/2, 3 1/2, 3	3, 3 1/2, 3 1/2	....	....
Waianae	9	K(2),12RM60	....	6, 1 1/3, 1 3/5	6, 1 3/5, 6	6, 6, 6	7, 7, 7	....	....
Kaiwiki	32	K,2RC60,9RM60	Krajewski	3, 3, 3	7, 7, 7	7, 7, 7	....	....	....
Kohala	40	K(2),3RC60,9RM60	3 1/2, 3 1/2, 5	3 1/2, 3 1/2, 3 1/2	5, 5, 5	5, 5 5	....	....	....
Kilauea	23	K,S,3RC60,9RM60	8/9, 8/9, 8/9	4, 4, 7	7, 4, 7	7, 4, 4	....	....	....
Kaeleku	47	K,2RC54,9RM60	Krajewski	3, 3, 3	5, 5, 5	5, 5, 5	....	....	....
Waimanalo	1	K,3RC54,9RM54	2/3, 2/3, 2/3	4, 4, 4	4, 4, 4	4, 4, 4	....	....	....
Halawa	29	K,2RC60,6RM50	8/9, 8/9	4, 4, 4	4, 4, 4	....	....	....	....
Union Mill	11	K,9RM60	....	4, 1 1/3, 2	6, 2 1/2, 6	6, 2 1/2, 6	....	....	....
Waimea	4	2RC48,12RM42	Krajewski	8/9, 8/9, 8/9	4, 4, 8	8, 4, 8	8, 4, 8	....	....
Olowalu	18	K,3RC48,9RM48	2/3, 2/3, 2/3	5, 5, 5	5, 5, 5	5, 5, 5	....	....	....
Niulii	39	K,9RM54	....	2, 2 1/2, 2	0, 0, 0	0, 6, 8	....	....	....

JUICE GROOVES

Factory No.	1st Mill Front Width	1st Front Depth	1st Front Pitch	1st Mill Back Width	1st Back Depth	1st Back Pitch	2nd Mill Front Width	2nd Front Depth	2nd Front Pitch	2nd Mill Back Width	2nd Back Depth	2nd Back Pitch	3rd Mill Front Width	3rd Front Depth	3rd Front Pitch	3rd Mill Back Width	3rd Back Depth	3rd Back Pitch
6	7/32	2 1/4	2 1/4	——	——	——	7/32	2 1/4	2 1/4	7/32	1 3/4	2	7/32	2 1/4	2 1/4	7/32	1 3/4	4
6	7/32	2 1/4	2 1/4	——	——	——	7/32	2 1/4	2 1/4	7/32	1 3/4	2	7/32	2 1/4	2 1/4	7/32	1 3/4	4
20	5/16	2	4 1/2	5/16	1 3/4	3 3/4	5/16	2	3 3/4	5/16	2	3 3/4	5/16	2	3 3/4	5/16	2	3 3/4
20	5/16	2	3 3/4	5/16	2	3 3/4	5/16	2	3 3/4	5/16	2	3 3/4	3/8	1 1/2	3 1/4	5/16	2	3 3/4
5	9/32	1 3/4	3	5/32	1 1/2	3	9/32	1 3/4	3	5/32	1 1/2	3	9/32	1 3/4	3	5/32	1 1/2	3
17	3/8	1 3/4	4 1/2	3/8	1 3/4	4	3/16	2	4	5/16	2	4	5/16	2	3	5/16	2	4
10	3/16	2	3	——	——	——	3/16	2	2 1/4	3/16	2	2 1/4	3/16	2	2 1/4	3/16	2	2 1/4
36	3/16	1 3/4	3	3/16	1 3/4	3	3/16	1 3/4	3	3/16	1 3/4	3	3/16	1 3/4	3	3/16	1 3/4	1 1/2
16	1/4	1 1/2	2	5/32	1 1/4	2	1/4	1 1/2	2	5/32	1 1/4	2	1/4	1 1/2	2	5/32	1 1/4	2
21	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3
34	1/4	1 1/2	2	3/16	1 1/2	2	1/4	1 3/4	2	3/16	1 3/4	2	1/4	1 3/4	2	3/16	1 1/2	2
27	1/4	2	3	1/4	1 1/4	2 1/4	1/4	1 3/4	3	1/4	1 1/4	2 1/4	1/4	1 3/4	3	1/4	1 1/2	2 1/2
30	3/16	1 1/2	3	3/16	1 1/2	3	3/16	1 1/2	2	3/16	1 1/2	2	1/8	1 1/2	2	1/8	1 1/2	2
7	1/4	1 1/2	2	1/8	1 1/2	2	1/4	1 1/2	2	1/8	1 1/2	2	1/4	1 1/2	2	1/8	1 1/2	2
13	——	——	——	——	——	——	3/16	1 1/2	3	3/16	1 1/2	3	3/16	1 1/2	3	3/16	1 1/2	3
25	——	——	——	——	——	——	3/8	1 1/4	2	3/16	1 1/4	2	1/4	1 1/4	2	3/16	1 1/4	2
33	1/4	2	2 1/2	1/8	1 3/8	1 3/5	1/4	2	2 1/2	1/8	1 3/8	1 3/5	1/4	2	2	1/8	1 3/8	2
2	3/16	1 3/4	3	3/16	1 1/2	3	1/4	1 1/2	2	3/16	1 1/2	2	3/8	1 1/2	4	5/32	1 1/2	2
12	5/16	1 1/2	3	1/4	1 1/2	2 1/4	1/4	1 1/2	3	1/4	1 1/2	2 1/2	3/8	1 1/2	3	5/16	1 1/2	2 1/2
14	3/16	1 1/2	3	3/16	1 1/2	2	3/16	1 1/2	3	3/16	1 1/2	2	3/16	1 1/2	3	3/16	1 1/2	3
35	3/4	1 3/4	2	5/16	1 3/4	2	7/16	1 3/4	2	5/16	1 1/2	2	5/16	1 3/4	2	7/16	1 3/4	2
41	1/4	1 3/8	2 1/2	3/16	1 1/8	2 1/2	1/4	1 1/4	3	3/16	1 1/4	2 1/2	1/4	1 3/8	3	3/16	1 1/4	2 1/2
19	1/4	1 1/4	3	1/8	1 1/2	1 1/2	1/4	1 1/4	3	1/8	1 1/2	1 1/2	1/4	1 1/4	3	1/8	1 3/4	1 1/2
15	1/4	1 1/2	2 1/4	1/4	1 1/4	2 1/4	1/4	1 1/2	2 1/4	1/4	1 1/4	2	1/4	1 1/2	2	1/4	1 1/4	2 1/4
43	1/4	1 1/2	2	——	——	——	1/4	1 1/2	2	——	——	——	1/4	1 1/2	2	——	——	——
24	1/8	1 1/2	2 1/4	1/8	1 1/4	2	1/8	1 1/2	2	1/8	1 1/4	2	1/4	1 1/2	3	1/8	1 1/4	2
37	5/32	1 3/4	2	5/32	1 3/4	2	5/32	1 3/4	2	5/32	1 3/4	2	5/32	1 3/4	2	5/32	1 3/4	2
38	1/4	1 1/2	2 5/8	1/8	1 1/2	2 5/8	1/4	1 1/2	2 5/8	1/8	1 1/2	2 5/8	1/4	1 1/2	2 5/8	1/8	1 1/2	2 5/8
3	7/16	2	3 1/2	5/16	1 1/2	3	7/16	1 7/8	2	5/16	1 1/2	3	1/8	1 1/2	3	3/16	1 1/2	3
31	1/4	1 1/4	2	1/4	1 1/4	2	5/16	1 1/2	2	1/4	1 3/8	2	1/8	1 1/4	2	1/8	1 1/4	2
26	——	——	——	——	——	——	——	——	——	1/4	1 3/8	2	5/16	1 1/4	2 7/8	1/4	1 3/8	2
9	——	——	——	——	——	——	——	——	——	3/16	1 1/4	2 1/2	3/16	1 1/4	2 1/2	3/16	1 1/4	2 1/2
32	1/4	1 1/4	3	1/4	1 1/4	3	3/16	1 1/4	3	3/16	1 1/4	3	3/16	1 1/4	3	1/4	1 1/4	3
40	1/4	1 1/2	2 1/2	1/4	1 1/2	2 1/2	3/16	1 1/2	2 1/2	3/16	1 1/2	2 1/2	1/4	2	2 1/2	1/4	2	2 1/2
23	3/16	1 1/4	2	3/16	1 5/16	2	3/16	1 3/4	2	3/16	1 3/8	2	1/4	1 1/4	2	1/8	1 1/4	2
47	1/4	1 1/2	2	1/8	1 1/4	2	1/4	1 1/2	2	1/8	1 1/4	2	1/4	1 1/2	3	1/8	1 1/4	2
1	5/32	1 1/2	2	5/32	1 1/2	2	5/32	1 1/2	2	5/32	1 1/2	2	5/32	1 1/2	2	5/32	1 1/2	2
29	1/4	1 1/2	2	1/4	1 1/2	2	1/4	1 1/2	2	1/4	1 1/2	2	....	....	....	....	....	....
11	——	——	——	——	——	——	1/4	1 1/4	3	1/4	1 1/4	3	1/4	1 1/4	3	1/4	1 1/4	3
4	——	——	——	——	——	——	1/4	1	2	3/16	1	2	5/16	1	2	1/8	1	2
18	3/16	1 1/4	2	3/16	1 1/4	2	3/16	1 1/4	2	3/16	1 1/4	2	3/16	1 1/4	2	3/16	1 1/2	2
39	1/4	1 3/4	3	1/4	1 1/8	3	1/4	1 1/8	3	1/4	1 1/4	3	3/16	1 3/8	3	——	——	——

4th Mill Front Width	4th Front Depth	4th Front Pitch	4th Mill Back Width	4th Back Depth	4th Back Pitch	5th Mill Front Width	5th Front Depth	5th Front Pitch	5th Mill Back Width	5th Back Depth	5th Back Pitch	6th Mill Front Width	6th Front Depth	6th Front Pitch	6th Mill Back Width	6th Back Depth	6th Back Pitch	Factory No.	Factory
7/32	2 1/4	2 1/4	7/32	1 3/4	3	....	....	....	....	....	....	....	....	....	....	....	....	6	H. C. & S. Co.
7/32	2 1/4	2 1/4	7/32	1 3/4	3	....	....	....	....	....	....	....	....	....	....	....	....	6	"
5/16	2	3 3/4	5/16	2	3 3/4	....	....	....	....	....	....	....	....	....	....	....	....	20	Oahu
3/8	1 3/4	1 3/8	5/16	2	3 3/4	....	....	....	....	....	....	....	....	....	....	....	....	20	"
9/32	1 3/4	3	5/32	1 1/2	3	9/32	1 3/4	3	5/32	1 1/2	3	9/32	1 3/4	3	5/32	1 1/2	3	5	Ewa
3/16	2	3	3/16	2	3	....	....	....	....	....	....	....	....	....	....	....	....	17	Waialua
3/16	2	2 1/4	3/16	2	2 1/4	3/16	2	2 1/4	3/16	2	2 1/4	....	....	....	....	....	....	10	Pioneer
3/16	1 3/4	3	3/16	1 3/4	2	....	....	....	....	....	....	....	....	....	....	....	....	36	Olaa
1/4	1 1/2	2	5/32	1 1/4	2	....	....	....	....	....	....	....	....	....	....	....	....	16	Haw. Sug.
5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3	5/16	1 1/2	3	21	Maui Agr.
1/4	1 3/4	2	5/32	1 3/4	2	....	....	....	....	....	....	....	....	....	....	....	....	34	Onomea
1/4	1 1/4	3	1/4	1 1/4	2 3/8	....	....	....	....	....	....	....	....	....	....	....	....	27	Lihue
1/8	1 1/2	2	1/8	1 1/2	2	....	....	....	....	....	....	....	....	....	....	....	....	30	Haw. Agr.
1/4	1 1/2	2	1/8	1 1/2	2	....	....	....	....	....	....	....	....	....	....	....	....	7	Hakalau
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	13	Honolulu
1/8	1 3/8	2	1/8	1 3/8	2	1/8	1 3/8	2	1/8	1 3/8	2	....	....	....	....	....	....	25	Kekaha
1/4	2	3	1/8	1 3/8	2	....	....	....	....	....	....	....	....	....	....	....	....	33	Hilo
1/4	1 1/2	2	5/32	1 1/2	2	....	....	....	....	....	....	....	....	....	....	....	....	2	Wailuku
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	12	McBryde
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	14	Makee
3/8	1 3/4	2	1/4	1 3/4	2	....	....	....	....	....	....	....	....	....	....	....	....	35	Honokaa
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	41	Laupahoehoe
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	19	Pepeekeo
1/4	1 1/2	2	1/4	1 1/4	2	....	....	....	....	....	....	....	....	....	....	....	....	15	Hamakua
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	43	Kahuku
1/8	1 1/2	2	1/8	1 1/4	2	....	....	....	....	....	....	....	....	....	....	....	....	24	Paauhau
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	37	Honomu
1/4	1 1/2	2 5/8	1/8	1 1/2	2 5/8	....	....	....	....	....	....	....	....	....	....	....	....	38	Koloa
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3	Waiakea
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	31	Hutchinson
5/16	1 5/16	3	——	——	——	....	....	....	....	....	....	....	....	....	....	....	....	26	Hawi
3/16	1 1/4	2 1/2	1/8	1 1/4	2 1/2	....	....	....	....	....	....	....	....	....	....	....	....	9	Waianae
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	32	Kaiwiki
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	40	Kohala
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	23	Kilauea
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	47	Kaeleku
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	Waimanalo
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	29	Halawa
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	11	Union Mill
5/16	1	2	1/8	1	2	....	....	....	....	....	....	....	....	....	....	....	....	4	Waimea
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18	Olowalu
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	39	Niulii